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LONG-RANGE GUNNERY AND HIGH-ALTITUDE BOMBING. A COMPARISON OF BALLISTIC MERIT.

BY

LOUIS THOMPSON, Ph.D.

I.

An attempt to measure the relative effectiveness of certain weapons or classes of armed ships is likely to be unsatisfactory, at least in definiteness of results, since so much depends on the conditions prevailing in their use. Conceivably, there are predicaments in which a fleet commander would prefer to have an additional plane carrier or two rather than another battleship division; likewise, it is presumed that there might occur a sequence of military conditions in which he would gladly give a considerable portion of his air "kingdom" for a battleship—that stablest of all sea-horses.

It is possible, nevertheless, to make some useful comparisons from the standpoint of ballistics, that is, with respect to available range, precision of fire-control, rate and volume of fire for a typical period of action, and the effect of actual hits when made. One may then choose innumerable combinations of the kinds of weapons in an investigation to find optimum distributions for specific purposes.

Probably no practical application of ballistics has ever aroused so general an interest as that which has been shown in the efficacy of the bomb as a major weapon. The possibilities in exploiting attack by air for the spectacular consummation of some of the steps of war have been emphasized

(Note.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the JOURNAL.)

in many popular presentations of the subject until it is quite widely accepted that there is no adequate defense and no other offense ballistically so devastating. As a consequence there is a recurring popular demand for "modernization" of the national defense into an air arm, while at the same time many believe that there is a better chance of avoiding a general collapse of civilization by giving up the principle of military preparedness altogether. These extremes meet evidently on the platform that the classical weapons will not offer a very useful protection against future military aggression. It is accordingly of some special interest to take stock of what evidence there may be at the present time of superior ballistic merit in any one of the equivalent-investment units of the several modes of defense. It should be readily granted that the best distribution of tools will involve a radical trend toward a new unit only in case the corresponding measures of merit are actually established as relatively high. At the same time, a peculiar and somewhat disconcerting twist is given the subject of disarmament if there is accepted the view that air attack is the most significant military device. A disarming formula must then be most importantly concerned with means for controlling the world's large air squadrons. It matters much less whether an air fleet is originally built for military purposes. A bomber for the attack of civilian centers can be made from a transport ship with a conversion efficiency undreamed for the transformation of surface ships into vessels of war. No expensive or slowly acquirable projection apparatus or armor are necessary and bombs are easy to build.

In certain respects there is a well-defined suggestion that the best outlook for a stabilized or controlled world armament status lies in the hope that the air arm is ballistically not all that has been sometimes claimed for it.

II.

It is appropriate in a study of ballistic qualities to begin with an examination of range performance. The maximum effective range of a battleship gun is not likely to exceed 35,000 to 40,000 yards. The "range" of a carrier bombing unit may be many times this value if one calculates the range as the distance to the target from the mother ship. There is

an important qualification, however, that a plane-and-bomb component leaving the ship in the general direction of the objective is not fully equivalent to the discharge of an aimed gun (unless it should be true that there is no important interference with the subsequent and all-important fire control operations which must be performed in the plane near the target; the corresponding operations of gunnery are conducted under more favorable conditions on the battleship). It is highly probable that the number of projectiles of a carrier battery of planes which will be aimed at a definite objective will average a considerably smaller value than the number leaving the ship. Although the carrier may be miles beyond the range of its objective's guns, no bombing hits will be made until its own individual projectors execute a quantitative aiming experiment of some complication, with a bomb range of 5,000 to 7,000 feet or less from the target, and subject to the presumably difficult condition of being themselves well within range of the anti-aircraft guns of the target. This latter condition is often passed over with scant interest and yet it is a fact that there is available for reference no practical experience in attempting to carry out the necessary precision fire-control operations in circumstances comparably precarious and disturbing. It is not quite legitimate to employ statistics obtained in bombing non-defending targets in peace-time as an index of performance in action. There is no close counterpart in the control of gun fire in action since this important part of gunnery operations is conducted in a well-protected and relatively stable ship. Since the number of projectiles which will be released and the precision with which they are aimed depend vitally on the effectiveness of anti-aircraft gunnery, it is evidently a very important matter in estimating the over-all standing of the bombing unit to have some reliable information concerning that effectiveness. It is of course impossible in peace-time to evaluate the effect of the mental hazard on the bomber in decreasing his precision.[1]

[1] That the anti-aircraft gunner is also under fire, or shortly to be under fire, does not alter the status of this factor. The burden of attack is with the bomber, and the reduction of his hitting ratio is the point under consideration. Similarly, it is unjustified to stress the destruction of anti-aircraft guns and controls by preliminary diving attack with small planes and bombs, unless the obvious protections of these areas from bomb fragments and blast are also presented.

It is well to note, however, that there is a substantial basis for expecting the casualty ratio for the bombing squadron to exceed frequently that value beyond which personnel has not been able in the past to perform effective service in military operations. To expect not only an orderly performance of duty but the completely successful execution of a quantitative fire-control experiment in such circumstances is hardly justified by the history of human experience in work of precision.

It will be assumed, in this connection, that the other anti-aircraft defense unit, the fighting plane, is not employed. If, then, it should turn out that anti-aircraft gunnery is of comparatively small effect, it will be necessary with these assumptions to concede that in range at least the carrier is distinctly superior to the battleship (the gunnery unit). If, however, the chance is fair or high of disabling the straight-flying heavy bomber during its aiming approach, then the bona fide "range" achievement and flexibility of the carrier (in battleship attack) is much less impressive because of the large proportion of projectiles which have no range at all. If for reasons other than those which originate in ballistic deficiencies in attack or the competency of anti-aircraft gunnery, the bombing planes can be prevented quite frequently from executing the required fire-control operation as, for example, by the successful use of small, fast planes for obscuring the target with smoke screens, or for direct attack, the same conclusions would be justified. In other words, how much a marked superiority in attainable range means as a degree of accomplishment depends greatly on the chance and cost of its practical attainment and of its useful application, taking into account, of course, conditions likely to prevail in action. For example, a gun can be built which will shoot fifty or sixty miles, but it is not practicable to put this weapon on ships. The chance of making hits on a naval target by gun fire at these ranges is vanishingly small and the rate of wear of the ultra-power gun would be so great as to render it nearly useless for the purposes of naval armament.

The ballistic questions requiring to be answered in order to develop the comparison of long-range gunnery and high-altitude bombing are here grouped as follows:

1. For conditions representative of bombing from above 10,000 feet, what is the probability of a disabling anti-aircraft hit before the bombs are released, that is, before the plane has reached the end of its aiming approach?

2. What is the probability of securing an actual hit on a major ship target, both for long-range gunnery and for high-altitude bombing?

3. What are the comparative rates of fire for the two methods of projection and the total volumes of fire possible in a limited engagement?

4. What are the relative severities of effect to be expected from impact by major caliber projectiles and by comparable bombs?

In order to discuss these questions with the advantage of a definite set of conditions, the following will be taken arbitrarily.

(*a*) The carrier is equipped with twenty-five bombing planes each carrying four large bombs.

(*b*) There are two anti-aircraft guns available for defense of the objective target against each formation of attacking planes. It is assumed that attack will be made in formation.

(*c*) The object of attack is a battleship in both cases (long-range gun fire and high-altitude bombing).

The first question concerns the number of bombs which will be released with the sight "on," that is, the number having any appreciable chance to be effective. The possible maximum is one hundred. The minimum, about equally unlikely, is zero. Four approaches are required in order to gain the advantage of carrying four (moderately) large bombs instead of one huge bomb. The advantage is somewhat analogous to that of spotting in gunnery although it develops not altogether for the same reasons. In the first place there is the simple gain in probability of securing *some* direct hits, the gain which corresponds to four trials instead of one. There is no statistical basis for the assumption that normal dispersion among the four bombs dropped simultaneously from one plane will produce the same effect. Here, unlike

the gunnery salvo, the systematic error of the group is of an entirely higher order than the accidental variation within the group. Second, there is likely to be a distinct improvement in precision with successive releases for conditions prevailing in action even with seasoned bombers. It is not necessary for a plane to be possessed of the capacity to "hover" over a target to gain the practical advantage of a spotting technique. With modern facilities for fire control there will probably occur quite frequently a surprising analogy between the improvements obtained in successive bombing runs in action and those of successive salvos in gunnery. The chance of getting enough direct hits from a single approach of a squadron at very high altitudes to disable a battleship is small enough to rule out for normal purposes the use of a one-bomb complement. It is a doubtful advancement in ballistic usage to place principal reliance in a type of offense for which the expectancy in direct hits in a complete action by a major ship unit is five or six at most. This is particularly true in case the projectiles are incapable of penetrating armored decks, and is an almost inevitable conclusion if one gives due consideration to the significance of a miscalculation or other source of error to be expected under the strain prevailing in action. A successful dodging maneuver by the target, to reduce the probable number of hits, executed once, would have the same significance, and the chance of success is not as low as it may seem.

Instead of setting up a single arbitrary estimate of the probability of disabling a plane by anti-aircraft gun-fire during a bombing approach, the following table considers a variety of values and the corresponding expectancy in total numbers of released (aimed) bombs.

Probability of Disabling Any Specific Plane During Approach.	Probable Number Disabled, Approach.				Total No. Aimed Bombs.
	No. 1.	No. 2.	No. 3.	No. 4.	
.05	1	1	1	1	90
.10	2	2	2	2	80
.20	5	4	3	3	59
.30	7	5	4	3	46
.40	10	6	4	2	32
.50	12	6	3	2	26

No change in probability was assumed to develop by virtue of the smaller number of units on successive runs. Ordinarily there would be a moderate change. Nor was any other allowance made for loss of part of the anti-aircraft battery after the first approach, merely assuming the ratio of guns to planes maintained. This presentation side-steps in a degree the principal statistical problem, that of actually finding the appropriate probability of a disabling hit for a particular occasion. However, the expectancies for conditions of interest are properly taken to lie well within the limits of this table. Much depends on conditions prevailing at the time, and those that are favorable for good bombing are generally favorable for good anti-aircraft gunnery. If we take seventy-five to forty as a measure of the total number of aimed bombs delivered by the one-carrier attack for conditions which warrant expecting 15 per cent. to 25 per cent. direct (bombing) hits, we shall hardly be radical in our prediction. Insofar as altitude variation is concerned, a change to one of the alternatives corresponding to that variation does not indicate an important change in the total *number of actual hits* because of the manner in which the bombing and anti-aircraft gunnery precisions now appear to change with altitude. But maximum bombing altitudes permitted by plane characteristics and weather conditions are evidently optimum, nevertheless.[2] This becomes an outstanding consideration

[2] The existence and location of an optimum altitude or belt of altitudes from which bombing may be conducted most effectively depend on the criterion of effectiveness and on the nature of the precision functions for bombing and for anti-aircraft gunnery with respect to altitude. The effect of increasing altitude on the number of bombing hits to be expected obviously depends on the size and shape of the target. For example, a very large target such as a city will experience about the same number of hits regardless of the altitude of the bomber. But an extremely small target, measured in terms of probable errors in range and deflection, will be hit nearly inversely as the square of the altitude, if each of the errors increases about linearly with the altitude. A target which is of the order of several probable errors in one dimension and small in the other dimension would correspondingly involve a (hit-probability) function more nearly a first power in the altitude.

The criterion of effectiveness may be either the total number of hits obtained, regardless of casualties among the attacking planes or there may be introduced a coefficient of credit for minimizing the casualty ratio. In the latter case the optimum status might involve a result with less than the maximum of attainable hits.

wherever the casualty ratio is high, not only in respect to the reduced loss of offensive air strength but also in its bearing on the difference in precision of fire control for bombing in action as compared with target practice conditions.

Accordingly, although the carrier may be considered greatly to out-range the battleship, in a sense, this advantage is gained by the use of ultra-mobile fire control and projector units, *themselves of extremely short range* and much more vulnerable than the projecting units of the battleship. It is not to be expected that half of the turrets of a battleship will be permanently out of commission by the time it has fired an equivalent amount, and even if many of the planes are not destroyed, they are disabled in effect when their bombs are released.

The precision function for anti-aircraft gunnery may be studied from the standpoint of the following arbitrary problem in chance. Suppose that within a limited volume σ_0, having a representative dimension r_0, an event is certain to occur whenever the boundary of this space is penetrated by a circulating object. Outside the boundary, the chance of the event is to be proportional to the reciprocal of the square of the distance of the object from the center of the volume σ_0. Suppose further that an outer space be arbitrarily taken as bounded by a probable deviation (probable error) in position of the moving object, within which the probability of the event is $\frac{c}{r_s^2} \cdot \Delta p_1$ where Δp_1 is the chance of the position being within a distance Δs of a specific point s within that space. Take the value of Δp_1 constant throughout the outer volume V, and proportional to the ratio $\frac{4/3\pi\Delta s^3}{V}$. This quantity is the fraction of the total probability which corresponds to the volume represented by the cell of radius Δs. Then the probability of the event (involving object position in either of the two volumes considered) is

$$p_a = \Delta p_1 c \sum_{r_0}^{r_m} \frac{1}{r_s^2} + \Delta p_1 n \qquad \left(n = \frac{r_0^2}{2\Delta s^3}\right)$$

[Outside the larger volume the values of $1/r^2$ are negligibly small and the summation is therefore not extended beyond this boundary.] For a second condition, take the linear dimensions of the outer space (the probable error) enlarged in the ratio $1/R$. The inner space σ_0 remains as in the first condition but contains fewer cells since the dimensions of each cell are enlarged in the ratio $1/R$ (total number for V unchanged). Accordingly

$$p_{(b)} = \Delta p_1 c R^2 \sum_{r_0}^{r_m} \frac{1}{r_s^2} + \Delta p_1 n R^3 + \Delta p_1 c \sum_{r_0}^{r_0 \cdot (1/R)} \frac{1}{r_s^2},$$

the third term representing the probability associated with those cells which are immediately outside σ_0 in the second condition but which were within σ_0 in the first condition.

The total volume of fire which the carrier can deliver is probably somewhat smaller than that which the battleship can generate in the short interval required to release the bombs after arrival of the planes in the field where aiming operations must be conducted. Unless the expectancy is relatively high that the total volume of bomb-fire is sufficient completely to disable the objective battleship, it may there-

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Writing

$$c \sum_{r_0}^{r_m} \frac{1}{r_s^2} \equiv M$$

(M being the equivalent number, for the outside volume, in cells of probability unity) there is obtained for the ratio

$$\frac{p_{(b)}}{p_{(a)}} = \frac{MR^2 + nR^3 + n(1 - R^3)\dfrac{\left(\dfrac{1}{r^2}\right)}{1/r_0^2}}{M + n},$$

the third term being

$$\frac{c}{M + n} \sum_{r_0}^{r_0(1/R)} \frac{1}{r^3} = \frac{n_1}{M + n} \frac{\text{mean } (1/r^2)}{1/r_0^2},$$

where

$$n_1 = n(1 - R^3).$$

Also

$$\left(\frac{1}{r^2}\right) = \frac{\text{Weighted } \sum_1^{s \text{ spherical layers}} 4\pi r_{(s)}^2 \cdot \dfrac{1}{r_s^2}}{\sum_1^s 4\pi r_{(s)}^2} = \frac{n_1}{\sum r^2} = \frac{1}{\bar{r}^2}$$

and

$$\frac{1}{\bar{r}^2} = \frac{\int dr}{\int_{r_0}^{r_0/R} r^2 dr} = \frac{3(r_0/R - r_0)}{(r_0/R)^3 - r_0^3}$$

$$= \frac{3r_0}{r_0^3} \frac{(1/R) - 1}{(1/R^3) - 1} = \frac{3}{r_0^2} \frac{(1 - R)R^2}{(1 - R^3)}$$

$$\therefore \quad \frac{p_{(b)}}{p_{(a)}} = \frac{MR^2 + nR^3 + 3n(1 - R)R^2}{M + n} = \left(1 + \frac{2n}{M + n}\right) R^2 - \frac{2n}{M + n} R^3.$$

Accordingly, the probability of the event (involving the inner or outer volumes) decreases with decreasing R at a rate roughly equivalent to a variation with R between the second and first power. For small ratios n/M the exponent is nearly 2, this being the value for the limit, $n = 0$.

In the case of anti-aircraft gunnery, the "event" is a direct hit on a vulnerable area of the plane, located at the center of σ_0, by a fragment from a bursting projectile somewhere in the two volumes considered. The constant c is determined by the vulnerable area. The probable a.a. control errors are large or high altitude bombing and the ratio $\frac{n}{M}$ is always small.

fore be assumed that the battleship offense has superiority on the following ballistic counts.

(1) Total volume of fire in an engagement of one or two hours duration.
(2) Rate of fire.
(3) Stability of projecting apparatus and facility for controlling fire under adverse conditions of weather and attack.

Flexibility, or the capacity to control the time of attack is clearly on the side of the air arm, considering only the isolated status of the two weapons which are being compared.

In order to justify a high degree of confidence in the ballistic equivalence or superiority of the carrier unit it is necessary to find a marked advantage either in precision of target practice results for high-altitude bombing as compared with gunnery precision, or in a distinctly greater effect to be expected from a direct hit. There is, in fact, a precision balance in favor of the bombing unit (that is, in respect to percentage of actual hits). But the greater rate of projection possible in action with the batteries of a battleship is likely to be sufficient to compensate for the deficiency, as far as the net rates of obtaining *hits* by the two principal units are concerned. The difference in expectancy of actual hits therefore offers little to choose between the two units during the first fifteen minutes of a typical action of either kind. After that, any fighting that is done will evidently be done by the opposing battleships.

The remaining question concerns the effect on a battleship target of actual hits. Lieut. L. A. Kniskern's commentary [3] on M. Rougeron's recent study [4] shows the present

[3] "Discussions" (Lieut. L. A. Kniskern (CC), U. S. Navy), *U. S. Naval Institute Proceedings*, February, 1932.

[4] M. Rougeron, "Protection Against Bombs and High-Angle Shell Fire," *U. S. Naval Institute Proceedings*, February, 1932; Translation from *La Revue Maritime*, May, 1931 by Commander Ralph T. Hanson, U. S. Navy. Rougeron also refers to a prevailing uncertainty in respect to the penetration of deck plate at angles above 60°–65°. Although data obtained for these conditions are subject to somewhat greater dispersion, current generalizations identify definitely the average actual penetrations both for projectiles and for armor piercing bombs,

trend in bomb design and the tendency to favor demolition bombs rather than those having the capacity to penetrate armor. It is not reasonable therefore to expect that a heavily armored battleship will be disabled completely unless several hits are made or unless a detonation occurs deep in the water close to the hull, when the action might approach that from torpedo attack. While the deck penetrations listed by Rougeron are greater than can be had in practice, it is true nevertheless that service major caliber projectiles constructed as bombs and dropped from altitudes which normally can be reached, may be expected to penetrate any existing deck identified in that reference. It is equally pertinent in this comparison to note that the same projectiles will penetrate these decks when fired from battleship guns at ranges which are relatively about as extreme as the altitudes required for the effective bomb release. But it is not true, of course, that projectiles of intermediate caliber will do better than this (or as well). If deck penetration must be improved it is best done (within reasonable limits) by *decreasing* muzzle velocity, not by reducing caliber.

If the demolition bomb is the basis for air attack the carrier unit is evidently inferior ballistically, or at a very unlikely best equal, to the battleship unit; equipped with armor piercing bombs, the comparison in offensive power leaves little to choose between the two, provided that the bombing planes from the carrier are able to reach their objective (a point 12,000 or 15,000 feet nearly above the proposed target), and then to conduct the essential fire-control operation. To appreciate that there is an emphatic condition of this nature it is only necessary to contemplate the comparative ease with which small, high-speed planes can sometimes interfere with this operation, the frequency of unfavorable weather conditions, and, also, the practicability of maneuvering the target ship during air attack from high altitudes.

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and provide a basis for comparisons at various scales (L. Thompson, "Ballistic Engineering Problems: Empirical Summaries," *U. S. Naval Institute Proceedings*, May, 1930). Rougeron's references to divided armor protection and to scale effects may properly be questioned. The penetration coefficient for a multiple-plate structure cannot be predicted from a solid-plate limit formula alone.

III.

The air unit has been discussed, in this comparison with the battleship, as if it were fully represented by the high-altitude bomber in the exhibition of its offense and nothing has been said about the other modes of attack which are often considered of great importance. These are the torpedo plane and dive-bombing techniques. In the case of the former there is a degree of analogy with high altitude bombing in the normal conditions to be met, but with advantage in offensive and defensive effectiveness hardly in its favor, at any rate from the standpoint of ballistic criteria. Precision of control, time of flight and the expectancy of anti-aircraft gunnery failure are among the factors which do not appear to benefit by a procedure which substitutes long water ranges for air trajectories from high altitudes. As a useful alternative, the torpedo plane may occasionally be of primary importance but as a component affecting the average ballistic rating of a carrier unit it would be assigned quite properly the status of an auxiliary. The dive-bomber cannot be discussed reliably for the reason that there is at present no quantitative index of ballistic excellence which is competent to identify its value. If it is advisable to proceed slowly in rating the principal established weapon of the air attack in respect to gunnery standards, it is much more justified to assume the skeptic's rôle in connection with a form of attack about which there are inadequate experimental ballistic summaries of precision and of measures of the effectiveness of gunnery antidotes. Its chief merit seems to develop in the element of surprise, the suddenness and brevity of attack, a factor which cannot be evaluated clearly in ballistic units. It should be noted however that of all the weapons of the air the dive bomber is probably the easiest target to hit by a defending battery that is ready to shoot. It must dive to low altitudes and through a very narrow cone, conditions which are favorable to a devastating counter fire. It is one thing to dive a plane at a target for the purpose of target practice and another to drive it deliberately and accurately into a dense cone of heavy machine gun bullets. If the relative number of hits is likely to be less with high-altitude bombers in the presence of effective anti-aircraft gun fire,

it is moderately certain to be still more disturbing to bombing precision to require to run directly into a hailstorm of this kind. The diving technique is a definite step away from the alternative of attack for armor penetration. It appears that the type of projector which plunges vertically presents no certain advantage in precision of fire control, comparing it with the high altitude horizontal bomber, possibly offers a net loss in the total number of hits which can be had per one-carrier attack, and in ruling out the alternative of heavy deck armor penetration makes a loss in total number of hits an important deficiency. The long dive of the plane in lieu of the corresponding flight of the projectile is a substitute for the aiming run of the horizontal bomber, and is a step farther in the direction of carrying the projector almost to the target. The very great uncertainty of the efficacy of this trend is enhanced in this case by the dependence of precision on human control in the last stages of flight and on the fair assurance that only one large bomb can be delivered per plane in one engagement. Allowing twice as many planes, it would still be necessary to develop a technique with twice the expectancy of a hit per release in order to come out about even ballistically. Although no attempt is made to estimate a definite status for this potentially important mode of attack, it seems reasonable to conclude that the relative ballistic standing of the air unit is not elevated by its inclusion, except as some coefficient of advantage can be assigned to diversity in the methods of attack.

Returning to the orthodox bombing technique, it is fair to say that there is no obscure factor associated with bombing which gives it extraordinary powers in respect either to precision or to penetration. The bomb is a somewhat less well controlled projectile than that ejected from a gun, largely because of the relative instability of the projector "mount." It has no advantage in penetration over a well-built gun projectile and the types of bomb now favored for practical reasons are vastly inferior in penetration (and therefore in damage to the sections below the armored deck). That bombing errors are less than those of long range gunnery in spite of the poorer aiming facilities is a consequence of the extremely short ranges employed. The bomber with a

horizontal range of 5,000 feet may do about as well as the gunner at 20,000 to 25,000 feet. The price to be paid for getting the individually portable projectors so close to the target as to gain this moderate advantage, and also the great flexibility, is rather high, and it is necessarily uncertain at the present time how far a large-scale investment of the kind can profitably be carried. The chance of losing 40 per cent. to 60 per cent. of the component projectors in a well-matched engagement by the time two to six projectiles have been released from each is not an attractive one in itself, and the evidence of the justifying superiority in important ballistic characteristics has not been obtained, and cannot very well be obtained in a short time. It is possible however to make important progress in the ballistic "laboratory," in the systematic study of those factors which are most significant in the proof of a weapon, and it appears that experimental work of this nature is quite properly accepted as a necessary or highly desirable prerequisite to the final definition of optimum distributions of weapons and best design characteristics. The kind of information sought is quantitative and can be had only by the laboratory method, not by the "demonstration."

On the whole, this state of affairs only emphasizes that the ultimate question is not, after all, whether there should be battleships, or whether a good fleet contains only carriers. The carrier itself, as well as its "projectors," is extremely vulnerable to attack even by ships with light guns or small bombers, yet no one would propose that battleships be substituted for carriers in their present or moderately extended representation. Defensively, at least, they are not ballistic alternatives, hardly more so than cruisers and submarines or fuel and repair ships. The air attack of ships may properly be considered a very important secondary or even primary weapon but it has not established itself as sufficiently competent under the many variations of conditions of weather and of defense to justify setting it apart ballistically as the primary reliance in a system of defense. Its maximum effectiveness as a weapon appears to develop as an integral part of a general system, both in the forces at sea and those on land. Its ballistic potency depends very fundamentally on effective timing and on a high degree of coördination in attack.

THE AUDIO TRANSFORMER AS A SELECTIVE AMPLIFIER.

BY

MYRON PAWLEY, Ph.D.

SUMMARY.

A selective amplifier is developed which is simple, and more flexible than other types. It utilizes an audio transformer with a variable series resistance in the primary circuit, and a variable secondary load capacitance both of which may be adjusted to give broad or narrow peaked amplification at any frequency within a wide range, or flat amplification throughout this range. Theoretical and experimental amplification curves are shown, and a transient solution gives the primary and secondary currents resulting when a voltage is suddenly applied to the amplifier. This analysis shows that the time constants for the circuit are comparable with those for other peaked amplifiers. Oscillograms are shown illustrating the transient behavior of the amplifier.

Selective amplifiers are used to discriminate against frequencies below or above a certain frequency, in recording frequencies only within a certain range which may be broad or perhaps very narrow, or to compensate for certain frequency characteristics in other apparatus. Common uses for such amplifiers are in communication networks,[1] in radio control of airport lights,[2] and in seismic prospecting. Conventional selective amplifiers consist of low pass, high pass, or band pass filters,[3] or peaked amplifiers.[4] In seismic prospecting it is sometimes desirable to select a very narrow range of frequencies somewhere within the range from 30 to 300 cycles per second. The peaked amplifier referred to above has been used for this purpose. It has the disadvantage that without an additional amplifier or complicated switching or plug-in arrangements it is not adapted to flat amplification throughout a wide range such as is sometimes

[1] Shea, "Transmission Networks and Wave Filters."

[2] B. Gostin, "Radio Control of Airport Lights," *Q. S. T.*, **14**, p. 19; April (1930).

[3] Shea, *op. cit.*

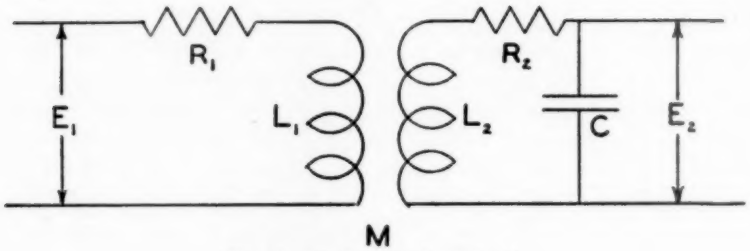
[4] Amer. Radio Relay League Handbook, 8th Ed., p. 68.

desirable in seismic prospecting. It was the purpose of the work prior to the writing of this paper to develop an amplifier of greater flexibility, adapted for broad or narrow peaked amplification at any frequency within a range from 30 to 300 cycles per second, or for flat amplification throughout this range. It was also desired to make the amplifier as simple and fool-proof as possible since it was to be used in seismic field work.

It is well known that audio transformers under certain conditions give peaked amplification characteristics, but it was thought worth while to investigate more fully the possibilities of using the transformer as a selective amplifier. The steady state analysis of the transformer given by Guillemin [5] suggests a method for securing selective amplification which is simple and more flexible than methods using other types of selective amplifiers.

Consider Fig. 1, which is the circuit of an audio transformer with a capacitance load. If we assume constant per-

FIG. 1.



Transformer with Capacitance Load.

meability, neglect distributed capacity effects, and consider $L_1 \gg CR_1R_2$ the steady state analysis of this circuit in the notation of Guillemin gives for the magnitude of the voltage amplification

$$\left|\frac{E_2}{E_1}\right| = \frac{M}{L_1} \cdot \frac{1}{|A + jB|}, \qquad (1)$$

where

$$A = \frac{\omega_1^2 - \omega^2}{r\omega\omega_2}; \qquad B = \frac{\omega_2^2 - \omega^2}{\omega_2^2}$$

[5] Guillemin, "Communication Networks," Vol. 1, p. 295.

$$\omega_1 = \sqrt{\frac{R_1}{C(R_1L_2 + R_2L_1)}}, \tag{2}$$

$$\omega_2 = \sqrt{\frac{L_1}{C(L_1L_2 - M^2)}}, \tag{3}$$

$$r = \frac{L_1\omega_1^2}{R_1\omega_2}. \tag{4}$$

ω_1 and ω_2 are called the essential frequencies because the essential frequency band is included between them.[6] r is a factor defined as the ratio of the voltage amplification at ω_2 to the voltage amplification at ω_1. For example with $r = 1$ we would have relatively flat amplification between the frequencies determined by ω_1 and ω_2, whereas with $r = 0.1$ the voltage amplification at ω_1 would be ten times that at ω_2 and the frequency characteristic would be quite sharply peaked in the neighborhood of ω_1.

In order to utilize the circuit of Fig. 1 as a practical selective amplifier with some degree of flexibility the relations (2), (3), and (4) were examined to determine what circuit parameters might be varied to give selective amplification of varying degrees of sharpness at different frequencies. *This may be done by varying the primary circuit resistance R_1 and the load capacitance C.* If an external variable resistance is inserted in the primary circuit R_1 may be increased until $R_1L_2 \gg R_2L_1$ and equation (2) becomes

$$\omega_1 = \frac{1}{\sqrt{L_2C}}. \tag{5}$$

Also

$$\omega_2 = \frac{1}{\sqrt{L_0C}} \tag{6}$$

if in equation (3) the leakage inductance of the transformer referred to the secondary, $\frac{L_1L_2 - M^2}{L_1}$ be replaced by L_0. The simple relations (5) and (6) are identical in form and show that ω_1 is the frequency at which the load capacitance

[6] Guillemin, *loc. cit.*, p. 291.

resonates with the transformer secondary inductance, and that ω_2 is the frequency at which the load capitance resonates with the transformer leakage inductance. Equations (5) and (6) are plotted in Fig. 2 which shows that the essential frequency band is lowered by increasing the load capacitance. Since the essential frequency response of the circuit is between ω_1 and ω_2 we have a convenient means for varying the position of this band by simple variation of the load capacitance. In order to vary the sharpness of the peak we use the relation (4). Substituting ω_1 and ω_2 from equations (5) and (6) into equation (4) we get

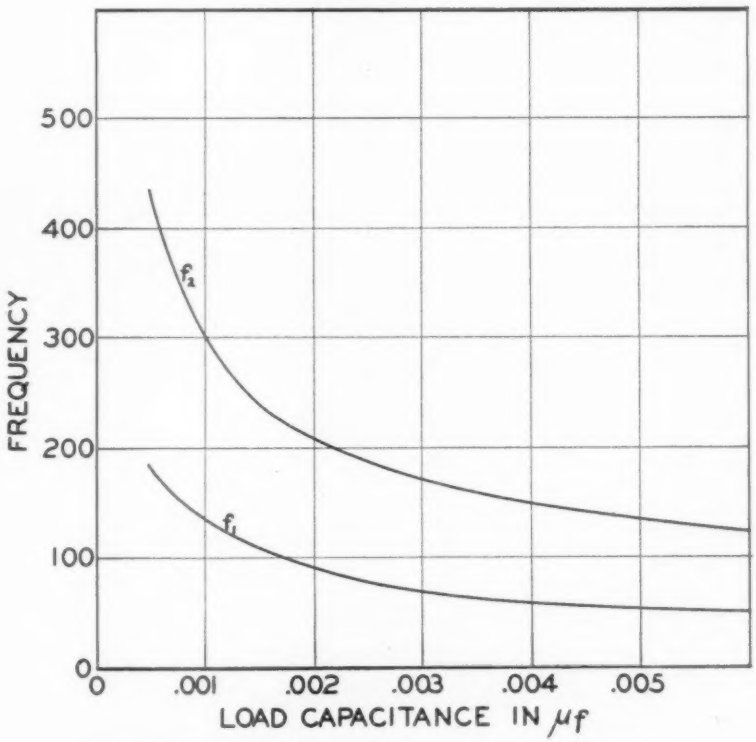
$$r = \left\{ \frac{L_1}{L_2} \sqrt{\frac{L_0}{C}} \right\} \frac{1}{R_1}. \tag{7}$$

This shows that for a fixed load capacitance the peaking factor r is inversely proportional to the primary circuit resistance R_1. Hence we can sharpen the peak by simply increasing an external primary circuit resistance, keeping the load capacitance constant. It will be shown later that the peak frequency remains approximately the same for wide variation in R_1 whereas the principal effect of varying the load capacitance is to shift the peak frequency. The circuit of Fig. 1 may therefore easily be adjusted for broad or narrow peaked amplification at any frequency within a wide range, the load capacitance C determining the peak frequency, and the primary circuit resistance R_1 determining the sharpness of the peak. It will also be shown later that by proper adjustment of R_1 and C the amplifier response may be made practically flat for a wide range of frequencies, or the frequency characteristic may be made to rise, or to fall over a considerable range of frequencies. For some purposes this flexibility is a distinct advantage over other types of peaked amplifiers where it is not possible to obtain flat amplification throughout a wide range of frequencies with the same amplifier circuit. Figures 2, 3, 4, and 6 are theoretical curves drawn to illustrate these frequency characteristics for a range up to approximately 500 cycles per second. They are computed for an audio transformer having the following constants:

$$\left.\begin{array}{ll} L_1 = 150\ h, & L_2 = 1475\ h, \\ M = 425\ h, & R_2 = 7480\ \Omega. \\ \text{Primary circuit resistance } R_1 \text{ variable.} & \\ \text{Load capacitance } C \text{ variable.} & \end{array}\right\} \quad (8)$$

Figure 2 shows the essential frequencies f_1 and f_2 as functions of the load capacitance C from equations (5) and (6). Figure 3

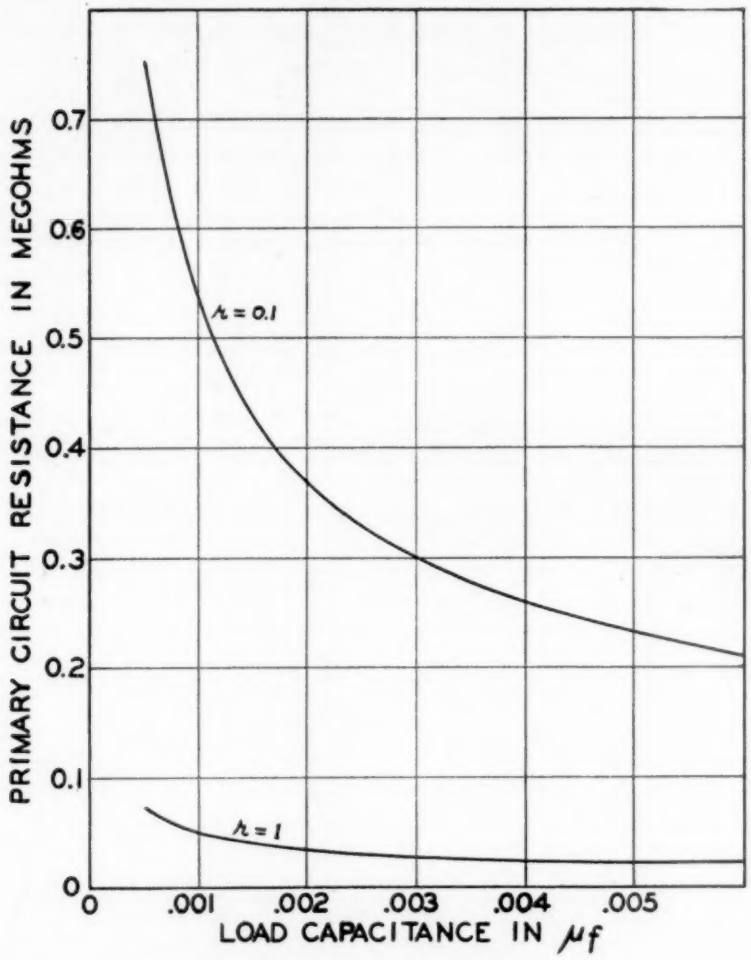
FIG. 2.



Upper and Lower Essential Frequencies as Functions of Load Capacitance.

shows the primary circuit resistance R_1 as a function of the load capacitance C for peaking factors $r = 1$, and $r = 0.1$ from equation (7). Figure 4 gives the theoretical voltage amplification E_2/E_1 as a function of the frequency f from equation (1). Curves (1), (2), and (3) of this figure are for a peaking

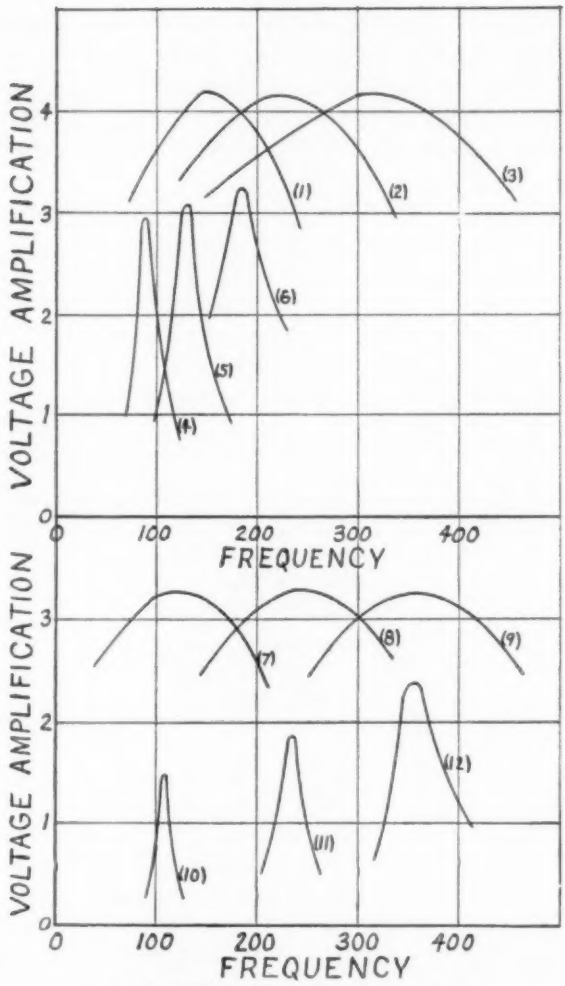
FIG. 3.



Primary Circuit Resistance as a Function of Load Capacitance.

factor $r = 1$, and load capacitances of 0.002 μf, 0.001 μf, and 0.0005 μf respectively. The proper values of R_1 to use for these curves are obtained from Fig. 3. Curves (4), (5), and (6) of the same figure are computed for the same values of load capacitances, 0.002 μf, 0.001 μf, and 0.0005 μf respectively, but for a primary circuit resistance $R_1 = 0.5 \times 10^6\ \Omega$,

FIG. 4.
FIG. 5.

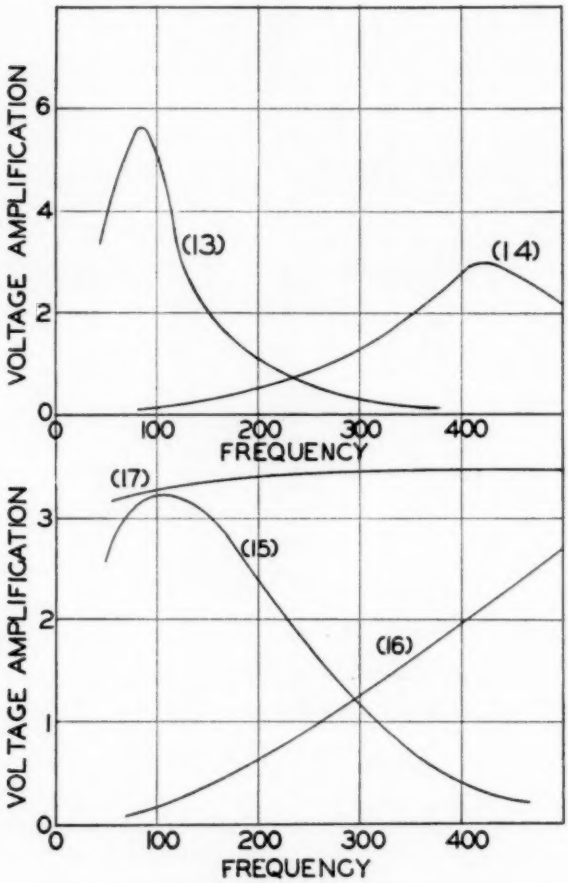


Theoretical Voltage Amplification Curves.
Experimental Voltage Amplification Curves.

giving peaking factors of $r = 0.075$, $r = 0.107$, and $r = 0.15$ respectively (from equation (7)). Figure 6 also shows the theoretical voltage amplification E_2/E_1 as a function of the frequency f from equation (1). Curve (13) of this figure is

computed for a primary circuit resistance $R_1 = 10^4\ \Omega$ and a load capacitance $C = 0.01\ \mu f$. Curve (14) of the same figure is computed for $R_1 = 10^6\ \Omega$ and $C = 0.0001\ \mu f$. Figures 5 and 7 are experimentally determined voltage amplification curves corresponding to the theoretical curves of Figs. 4 and 6 respectively. They were not obtained with the transformer used in the computation of the theoretical curves, since this

FIG. 6.
FIG. 7.



Theoretical Voltage Amplification Curves.
Experimental Voltage Amplification Curves.

transformer was not available when the measurements were made. However they were obtained from a commercial type of transformer and they provide a good qualitative verification of the theory. The experimental curves (7), (8), and (9) of Fig. 5 were obtained with a primary circuit resistance of 6000 Ω and load capacitances of 0.006 μf, 0.002 μf, and 0.0005 μf respectively. The more sharply peaked curves of this figure, (10), (11), and (12) were obtained with a primary circuit resistance of 10^5 Ω and with load capacitances the same as for curves (7), (8), and (9) of this figure, 0.006 μf, 0.002 μf, and 0.0005 μf respectively. The experimental curve (15) of Fig. 7 was obtained with a primary circuit resistance of 3000 Ω and a load capacitance of 0.01 μf. The experimental curve (16) of the same figure was obtained with a primary circuit resistance of 0.5×10^6 Ω and a load capacitance of 0.0001 μf. The curve (17) of this figure was obtained with a primary circuit resistance of 3000 Ω and a load capacitance of approximately 50 $\mu\mu f$.

The discrepancies between experiment and theory may be explained readily by consideration of the assumption made in the theoretical development that the permeability remains constant. The experimental curves of Fig. 5 show that for a fixed load capacitance an increase in primary circuit resistance from 6000 Ω to 10^5 Ω sharpens the peak without appreciably shifting the peak frequency. The corresponding theoretical curves of Fig. 4 show that such an increase in primary circuit resistance not only sharpens the peak but also lowers the peak frequency. In an actual transformer the permeability of the core and hence the transformer inductances, including the leakage inductance, decrease when the primary circuit resistance is increased far enough to make the primary current very small.[7] Equations (5) and (6) show that with these decreases in the transformer inductances there is a corresponding increase in the essential frequencies ω_1 and ω_2. This explains why increasing the primary circuit resistance merely sharpens the amplification peak without decreasing the peak frequency as indicated in the theoretical curves of Fig. 4. The theoretical curve (13) of Fig. 6 shows a very

[7] Morecroft, "Experimental Radio Eng.," p. 262.

high peak at about 85 cycles per second whereas the corresponding experimental curve (15) of Fig. 7 indicates no such high peak. This may be explained by examination of equation (7).

$$r = \left\{ \frac{L_1}{L_2} \sqrt{\frac{L_0}{C}} \right\} \frac{1}{R_1},$$

where the leakage inductance

$$L_0 = \frac{L_1 L_2 - M^2}{L_1}.$$

When the primary circuit resistance R_1 is low, as it was for the experimental curve (15) of Fig. 7, the increased primary current partially saturates the transformer core lowering its permeability and hence the transformer inductances. This in turn decreases the leakage inductance and results in decreasing the peaking factor r according to equation 7. This decrease in r lowers the voltage amplification as may be seen by examination of equation (1). Hence we would not expect such a high peak as given by curve (13) of Fig. 6. The amplification peaks given by the experimental curves (10), (11), and (12) of Fig. 5 are lower than the corresponding amplification peaks of the theoretical curves (4), (5), and (6) of Fig. 4. This may also be explained by the decrease in leakage inductance and its effect upon the peaking factor r as given by equation (7). Only in this case the decrease in leakage inductance results from the low primary current caused by high values of primary circuit resistance R_1. Experimental curve (17) of Fig. 7 shows a relatively flat amplification characteristic over the range from 50 to 500 cycles per second. It was obtained by using a primary circuit resistance of 3000 Ω and a load capacitance of approximately 50 $\mu\mu f$. The leakage inductance of the transformer which was examined theoretically is so high (273 henrys) that it could not be used to obtain flat amplification over a wide frequency range. The upper essential frequency

$$\omega_2 = \frac{1}{\sqrt{L_0 C}}$$

is too low.

In order to obtain some idea of the transient behavior of the amplifier circuit of Fig. 1 when adjusted for sharply peaked amplification a transient analysis was carried out to obtain the primary and secondary currents resulting from a suddenly applied continuous voltage E. The transformer constants are the same as those given in (8), the load capacitance being 0.001 μf, and the initial conditions being $i_1 = 0$, $i_2 = 0$, and $q_2 = 0$. The solution was carried out for two different values of primary circuit resistance in order to show the effect of increasing this resistance. The solutions give For R_1 $0.5 \times 10^6\ \Omega$:

$$\left.\begin{aligned} i_1 &= -202 \times 10^{-8} E\epsilon^{-17900t} + 40.8 \times 10^{-8} E\epsilon^{-86t} \\ &\qquad \cos(820t + \psi) + 200 \times 10^{-8} E, \\ i_2 &= 58 \times 10^{-8} E\epsilon^{-17900t} - 58.2 \times 10^{-8} E\epsilon^{-86t} \\ &\qquad \cos(820t + \psi'). \end{aligned}\right\} \quad (9)$$

For $R_1 = 10^6\Omega$:

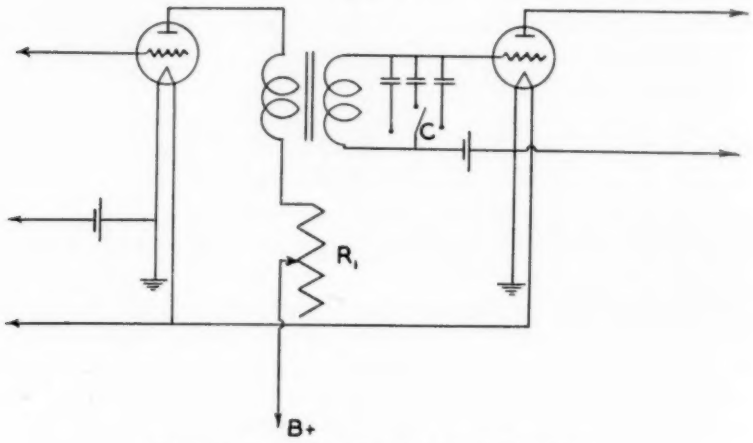
$$\left.\begin{aligned} i_1 &= -90.5 \times 10^{-8} E\epsilon^{-35900t} - 14.3 \times 10^{-8} E\epsilon^{-45t} \\ &\qquad \cos(780t + \phi) + 100 \times 10^{-8} E, \\ i_2 &= 26 \times 10^{-8} E\epsilon^{-35900t} - 26 \times 10^{-8} E\epsilon^{-45t} \\ &\qquad \cos(780t + \phi'). \end{aligned}\right\} \quad (10)$$

The solutions for this particular case show that the purely exponential components of the currents die away very rapidly and that doubling the primary circuit resistance approximately halves the time constant for these components. The time constant for the oscillatory components of the currents are much higher and they are approximately doubled by doubling the primary circuit resistance. The solutions also show that doubling the primary circuit resistance approximately halves the amplitude coefficient of each of the current components.

Figure 8 shows a practical amplifier circuit using the circuit of Fig. 1 as a selective amplifier. It has proved to be effective not only at frequencies below 500 cycles per second but also at 1000 cycles per second as a peaked amplifier for the reception of continuous wave radio telegraphic signals. The peak frequency may be shifted by varying the load

capacitance C, the peak frequency decreasing with increase of C. The sharpness of the peak is controlled by the variable resistance R_1 becoming sharper as R_1 is increased. With the adjustment of R_1 and C corresponding to those for curve (17) of Fig. 7 the amplification is practically flat throughout the audio range. This will only be true provided a high grade audio

FIG. 8.



Schematic Diagram for a Practical Selective Amplifier.

transformer is used in the circuit. It is important to note that in an amplifier circuit such as shown in Fig. 8, or more particularly in a multistage amplifier, there are many factors which affect the overall frequency response. For example, one poor input or output transformer will undo the effect of much high grade apparatus in other parts of the amplifier. If the circuit of Fig. 1 is used between two tubes such as in the amplifier of Fig. 8 it must be remembered that the plate impedance of the input tube makes up part of the primary circuit resistance of the transformer, that this plate impedance is a function of the plate and grid voltages of that tube,[8] and that therefore changes in these voltages will affect a change in the frequency response of the amplifier. Also, the input resistance of the output tube depends upon the grid bias on that tube. If the latter is too low the input resistance

[8] Henney, "Principles of Radio," p. 275.

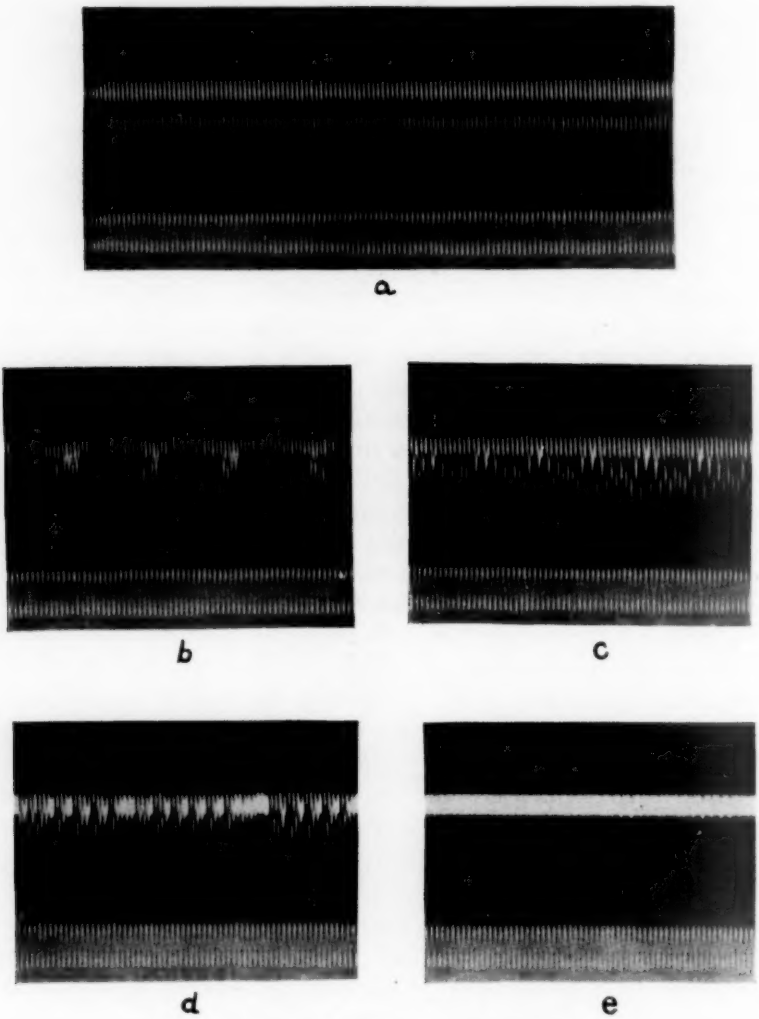
decreases and this shunt resistance across the secondary of the transformer will affect its frequency response. Normally this shunt resistance is very high, of the order of $10^9\Omega$ and has little effect on the performance of an amplifier such as that of Fig. 8. The general effect of a lower shunt resistance across the load capacitance of the amplifier of Fig. 8 is to flatten the amplification peaks.[9]

The oscillograms of Fig. 9 illustrate the transient performance of this amplifier when adjusted for sharply peaked amplification at about 110 cycles per second (see curve (10) Fig. 5). The lower wave on all the diagrams is a 100 cycle timing wave. Diagram *a* represents the output voltage obtained from a beat-frequency oscillator set at approximately 110 cycles per second. Diagram *b* represents this 110 cycle voltage having superimposed upon it a voltage from a 60 cycle door buzzer, and diagram *d* represents this door buzzer voltage alone. The oscillograms *c* and *e* represent the response of the peaked amplifier to the voltages *b* and *d* respectively. They illustrate the ability of the amplifier to select a single frequency from disturbing voltages. The white line in diagram *e* results from the shadow of the oscillograph string. The string barely moved with the buzzer voltage *d* applied to the peaked amplifier.

In this paper a new type of amplifier has been developed which is simple, and more flexible than existing types of selective amplifiers. Simplicity and flexibility are distinct advantages. In seismic prospecting, for example, it is frequently desirable to select vibrations within a certain frequency range, which is sometimes very narrow and sometimes very broad. Simplicity is desirable in order to make the field equipment as light and fool-proof as possible. Selective amplifiers in common use cannot be adjusted for flat amplification throughout a wide frequency range. If flat amplification is desired in addition to peaking ability an extra amplifier must be provided or complicated switching or plug-in arrangements introduced. The amplifier here described consists of a single amplifier circuit which may easily be adjusted by manipulation of two controls for broad or narrow

[9] Guillemin, "Communication Networks," p. 302.

FIG. 9.



Oscillograms Illustrating Transient Behavior of Amplifier.

peaked amplification at any frequency within a wide range, or for flat amplification throughout this range.

BIBLIOGRAPHY.

GUILLEMIN, ERNST A. Communication Networks. New York: John Wiley and Sons, Inc., 1931.

BUSH, VANNEVAR. Operational Circuit Analysis. New York: John Wiley and Sons, Inc., 1929.

HENNEY, KIETH. Principles of Radio. New York: John Wiley and Sons, Inc., 1929.

MORECROFT, JOHN H. Experimental Radio Engineering. New York: John Wiley and Sons, Inc., 1931.

——. Principles of Radio Communication. New York: John Wiley and Sons, Inc., 2d Edition, 1927.

SHEA, T. E. Transmission Networks and Wave Filters. New York: D. Van Nostrand Company, Inc., 1929.

Irish Moss.—CHARLES H. LAWALL AND JOSEPH W. E. HARRISSON (*Jour. Am. Pharm. Asso.*, 1932, xxi, 1146–1153) have examined eight authentic specimens of natural and sun-bleached Irish moss from the coast of Massachusetts, and found them to be free from sulphites. Six imported samples contained sulphites, from 920 to 4080 parts per million. These imported samples had been bleached with sulphur dioxide. Irish moss, which is a dried sea alga (*Chrondrus crispus*), is also called carrageen. It is offical in the National Formulary V. Several foreign pharmacopœias have rubrics of purity which set a maximum sulphur dioxide (sulphite) content of Irish moss at approximately 300 parts per million. When this product is used in foods, drinks, or medicines, it should be free from sulphites. At Scituate, Massachusetts, the headquarters of the American industry, formerly 850 people were employed, and the annual production was about 22,000 barrels. Today about a dozen men are at work, and produce from 300 to 900 barrels per annum.

J. S. H.

Cyanide Poisoning.—J. C. GEIGER (*Jour. Am. Med. Asso.*, 1932, xcix, 1944–1945) describes intravenous injection of 50 cc. of a sterile aqueous 1 per cent. solution of methylene blue (methylthionine chloride U. S. P.) in the treatment of poisoning due to ingestion of potassium cyanide. The patient also receives gastric lavage with an aqueous solution of sodium bicarbonate. In a case of poisoning, the patient had ingested approximately 1 gram of potassium cyanide; he was comatose and cyanotic, had bright vermillion lips, and breathed in a shallow and irregular fashion. Other symptoms were also noted. Within five minutes after the injection of methylene blue, he was again conscious, and essentially normal except for a severe chill and an apparent flushing; within fifteen minutes, recovery was complete. The same treatment is recommended for poisoning by carbon monoxide.

J. S. H.

EXPERIMENTAL DETERMINATION OF THE FLAME TEMPERATURES OF COMPLEX MIXTURES OF COMBUSTIBLE GASES AND A METHOD FOR CALCULATING THEM.*

BY

BERNARD LEWIS,† HENRY SEAMAN ‡ and G. W. JONES.§

INTRODUCTION.

In previous reports [1, 2, 3, 4] results were published giving the flame temperatures of many hydrocarbon-air mixtures, of mixtures of methane and oxygen, methane-hydrogen and methane-acetylene with air and of ammonia and its products of dissociation with air. The above reports should be consulted for details regarding the method of making flame-temperature determinations.

In the present report data are given showing how the flame temperatures of hydrogen, methane and carbon monoxide are affected by the addition of various amounts of nitrogen and carbon dioxide. The results have industrial importance, because they show to what extent the addition of these inert gases depresses the available maximum flame temperatures of such mixtures when they are burned with air.

Practically all the mixed gases used industrially contain one or more of the following constituents: carbon dioxide,

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§ Chemist, U. S. Bureau of Mines, Pittsburgh Experiment Station, Pittsburgh, Pa.

[1] Loomis, A. G. and Perrott, G. St. J., *Ind. Eng. Chem.*, **20**, 1928, p. 1004.

[2] Jones, G. W., Lewis, Bernard, Friauf, J. B. and Perrott, G. St.J., *Journ. Amer. Chem. Soc.*, **53**, 1931, p. 869.

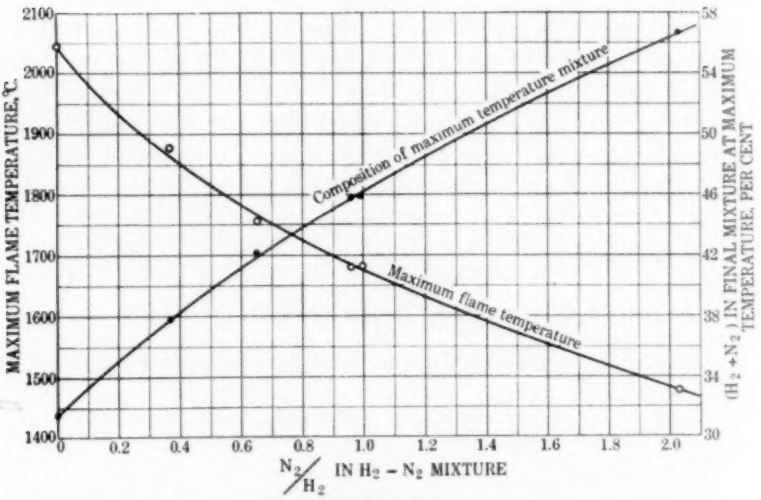
[3] Jones, G. W., Lewis, Bernard and Seaman, Henry, *Journ. Amer. Chem. Soc.*, **53**, 1931, p. 3992.

[4] Jones, G. W., Lewis, Bernard and Seaman, Henry, *Journ, Amer. Chem. Soc.*, **54**, 1932, p. 2166.

illuminants, hydrogen, carbon monoxide, methane, ethane, and nitrogen. The combustibles occurring in greatest proportion in various kinds of manufactured and producer gas are methane, hydrogen, and carbon monoxide. If one knows the flame temperatures of methane or hydrogen or carbon monoxide, each mixed with various amounts of nitrogen and carbon dioxide, the results, when tabulated in a manner described by Jones [5] for the calculation of limits of inflammability of mixed gases, may be applied directly to the calculation of flame temperatures.

Therefore, these data have been used to calculate the flame temperatures of complex combustible gas mixtures containing various proportions of the inert gases, nitrogen and carbon dioxide. The only requirement for making quite accurate calculations of maximum flame temperatures of mixed gases, such as manufactured or producer gas, when burned with air is a knowledge of the composition of the mixture. A number of such mixtures have been tested, by comparing their actually determined flame temperatures with

FIG. 1.



Maximum flame temperatures and composition of mixtures at maximum temperatures. H_2-N_2 air mixtures.

[5] U. S. Bureau of Mines Technical Paper No. 450.

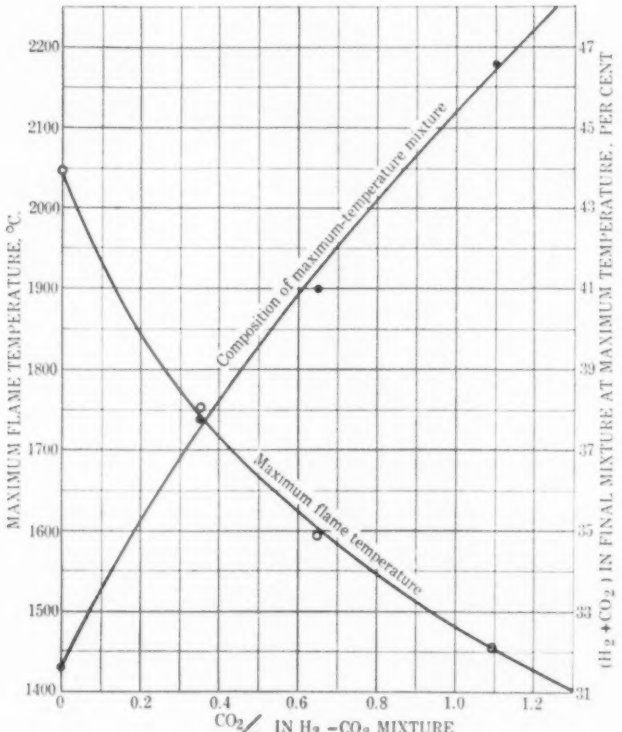
the flame temperatures calculated by the method to be described. The accuracy and limitations of the method will be discussed later in this report.

EXPERIMENTAL DATA.

Maximum Flame Temperatures of Hydrogen-Nitrogen Mixtures.

Mixtures containing hydrogen and nitrogen were so prepared as to include all proportions that might be found in manufactured and producer gases. The flame temperatures of each of these mixtures were determined for various proportions of air, and curves drawn, similar to those in Fig. 1 of reference 4, showing the flame temperatures obtained for

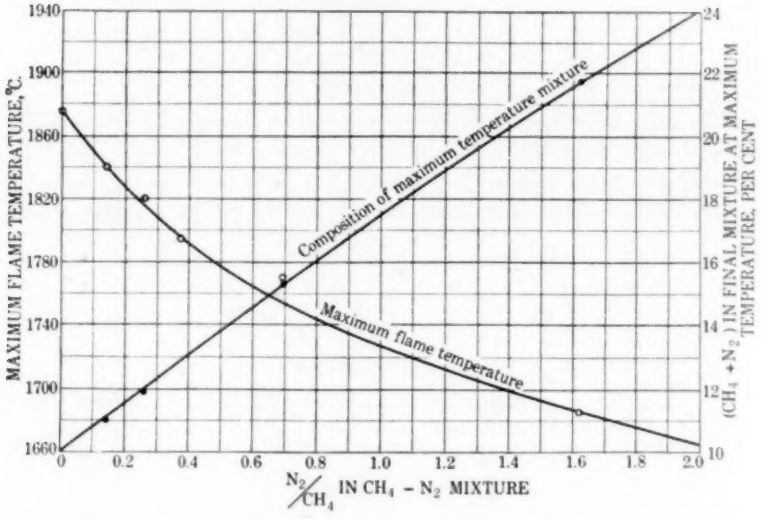
FIG. 2.



Maximum flame temperatures and composition of mixtures at maximum flame temperatures. H_2-CO_2 air mixtures.

all proportions of air, from the leanest to the richest mixtures which would burn satisfactorily in the burners. The maximum flame temperature of each mixture with air as well as the amount of hydrogen and nitrogen in this maximum flame temperature mixture was determined. Space does not permit the reproduction of all of these curves. Of most importance (industrially), however, are the maximum flame temperatures which are given in Fig. 1 for the various mixtures of hydrogen and nitrogen when burned with air. There is also shown the

FIG. 3.



Maximum flame temperatures and composition of mixtures at maximum temperatures. $CH_4 - H_2$ air mixtures.

composition of the hydrogen-nitrogen mixtures which give these maximum flame temperatures. Both sets of values are needed for the calculation of the maximum flame temperatures of mixed gases.

It is seen that pure hydrogen burned with air gives a maximum flame temperature of 2045° C. and as nitrogen is added to the hydrogen the maximum flame temperature drops off very rapidly. For example, when the ratio of nitrogen to hydrogen in the original mixture before addition of air is

0.5, the maximum flame temperature drops to 1812° C. or 233° below that of pure hydrogen in air.

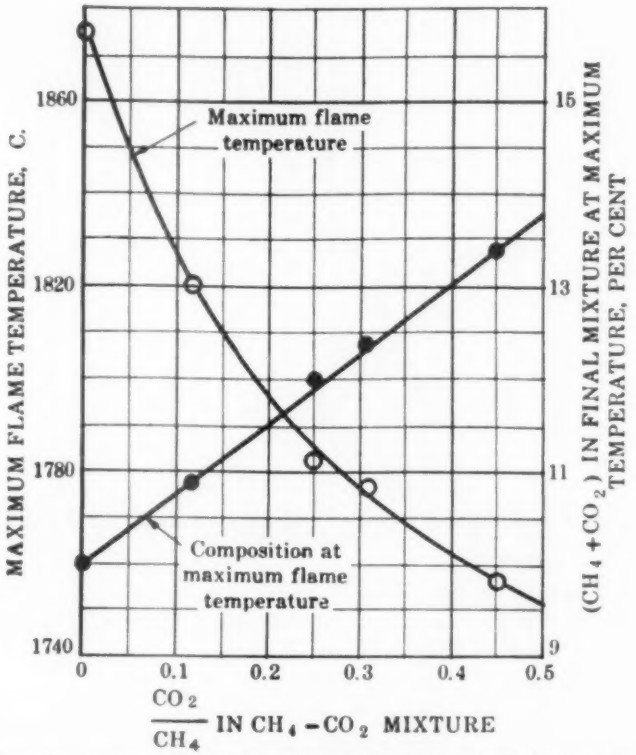
Maximum Flame Temperatures of Hydrogen-Carbon Dioxide Mixtures.

Similar tests were made with hydrogen-carbon dioxide mixtures and the curves for the maximum flame temperatures of various mixtures are given in Fig. 2. The results show that the addition of carbon dioxide decreases the maximum flame temperature of hydrogen more than equal amounts of nitrogen. This is, as might be expected, due to the higher heat capacity of carbon dioxide.

Maximum Flame Temperatures of Methane, Carbon Dioxide, and Nitrogen Mixtures.

Similar graphs are given for methane-nitrogen and methane-carbon dioxide mixtures in Figs. 3 and 4.

FIG. 4.

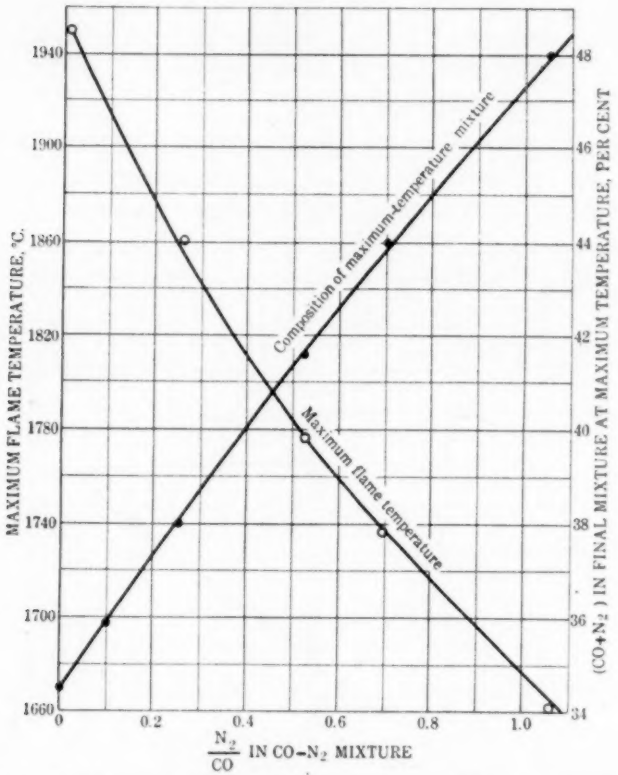


Maximum flame temperatures and composition of mixtures at maximum flame temperatures. CH_4-CO_2 air mixtures.

Maximum Flame Temperatures of Carbon Monoxide and Carbon Dioxide and Nitrogen Mixtures.

Likewise graphs are given for carbon monoxide-nitrogen and carbon monoxide-carbon dioxide mixtures in Figs. 5 and 6. The maximum flame temperature of pure carbon monoxide in air was redetermined and found to be 1950° C., within 10°

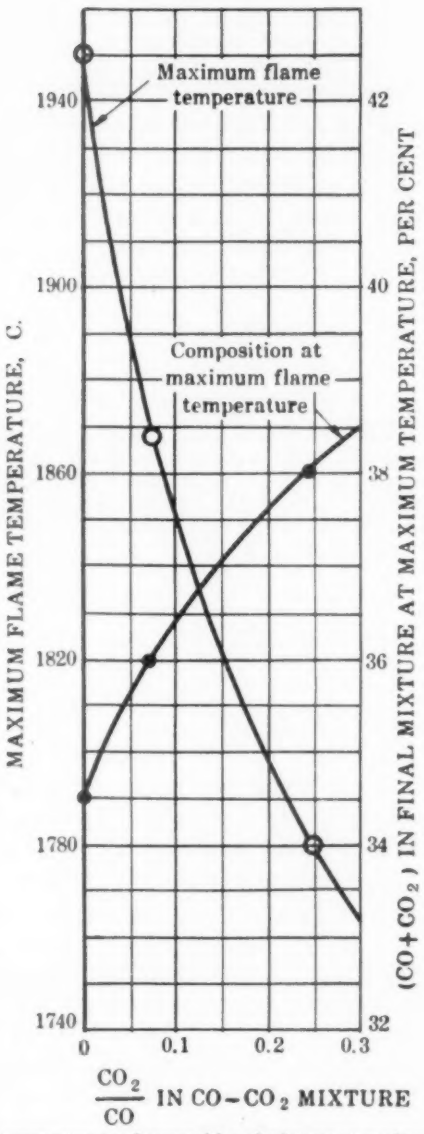
FIG. 5.



Maximum flame temperatures and composition of mixtures at maximum temperatures. CO—N_2 air mixtures.

of a previously determined value.[1] In these tests, as in all other tests, the combustible-air mixtures were saturated with water vapor at a temperature of 21–25° C. Compared with this, the value calculated by the method outlined in reference 2 is 2100° C., the difference of 150° C. being somewhat greater than can be accounted for by radiation losses.

FIG. 6.



Maximum flame temperatures and composition of mixtures at maximum temperatures. $CO-CO_2$ air mixtures.

By means of the data given in the above sets of curves the flame temperatures of most mixed combustible gases can be calculated.

Flame Temperatures of Mixed Combustible Gases.

To determine the accuracy of the calculation of the flame temperatures of mixed gases and to obtain information on the maximum flame temperatures of various industrial gases, experiments were made with a number of different gases. The types of gases and their composition on an air-free basis are given in Table 1. No. 1 was a mixed coal gas from

TABLE 1.

Composition of Gases Used, Air-free Basis.

Composition, Per cent. by Volume.

"Gas."	CO.	H_2.	N_2.	CH_4.	C_2H_6.	CO_2.	Illuminants.	Total.
1. Mixed coal gas	11.8	49.8	4.2	25.8	1.5	2.4	4.5	100
2. Carbureted water gas	23.5	35.9	15.4	9.0	2.7	3.5	10.0	100
3. Electrolene gas	24.7	69.7	1.3	1.7	—	2.6	—	100
4. Anthracite producer gas	27.6	16.9	49.5	0.8	—	5.1	0.1	100
5. CO-H_2-N_2 mixture	31.9	22.7	45.4	—	—	—	—	100
6. do.	37.0	27.1	35.9	—	—	—	—	100
7. do.	50.1	35.5	14.4	—	—	—	—	100
8. H_2-CO mixture	58.5	41.5	—	—	—	—	—	100

Milwaukee, Wisconsin; No. 2, a carbureted water gas from Harrison, New Jersey; No. 3, "Electrolene" gas from the General Electric Co.; No. 4, anthracite producer gas from the Stewart Hartshorn Co., E. Newark, New Jersey; Nos. 5, 6, 7 and 8 were synthetic gases produced by mixing hydrogen and carbon monoxide in approximately the same relative proportions as found in producer gas and then adding various proportions of nitrogen. These synthetic gases were prepared to determine the effect of various proportions of nitrogen on the flame temperatures of hydrogen and carbon monoxide mixtures, for it was desired to know whether the addition of large amounts of nitrogen was in any way connected with the variation between the observed and calculated maximum flame temperatures for producer gas (see below). Nos. 9, 10, 11, and 12 (Table 2) are binary mixtures of methane-hydrogen and methane-acetylene borrowed from a previous

TABLE 2.

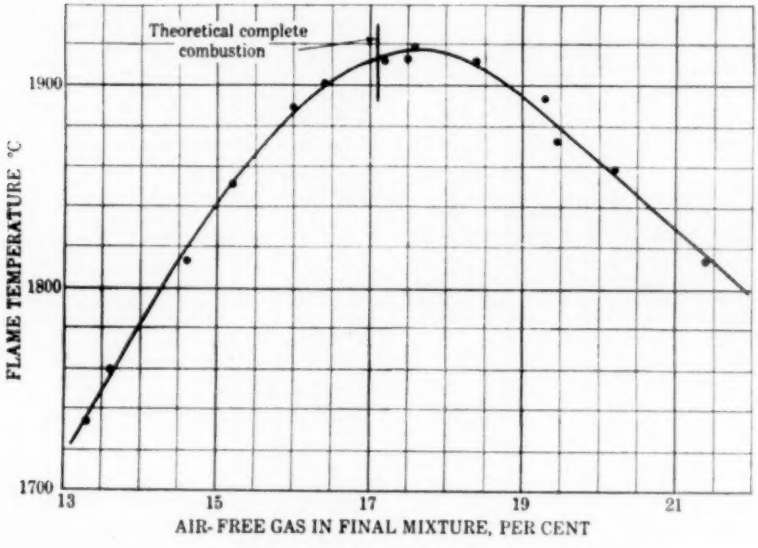
Summary of Observed and Calculated Results of Maximum Flame Temperatures.

"Gas."	Observed.		Calculated maximum flame temperature, ° C.					
	Maximum flame temp., ° C.	Per cent. gas in maximum temp. mixture.	Lowest.	Highest.	Equi-ratio.	Calculated—observed.		
						Lowest.	Highest.	Equi-ratio.
1. Mixed coal gas	1918	17.6	1907	1915	1910	−11	− 3	− 8
2. Carbureted water gas	1930	18.8	1885	1897	1885	−45	−33	−45
3. Electrolene gas	1983	30.8	1973	1990	1973	−10	+ 7	−10
4. Anthracite producer gas	1663	46.7	1617	1622	—	−46	−41	—
5. 22.7% H_2, 31.9% CO, 45.4% N_2	1718	45.0	1682	1725	1712	−36	+ 7	− 6
6. 27.1% H_2, 37.0% CO, 35.9% N_2	1812	41.7	1765	1817	1780	−47	+ 5	−32
7. 35.5% H_2, 50.1% CO, 14.4% N_2	1940	36.4	1900	1926	1915	−40	−14	−25
8. 41.5% H_2, 58.5% CO	2005	32.7	1993	1993	—	−12	−12	—
9. 59.5% CH_4, 40.5% H_2	1900	13.7	1905	1905	—	+ 5	+ 5	—
10. 30.3% CH_4, 69.7% H_2	1927	18.9	1946	1946	—	+19	+19	—
11. 78.6% CH_4, 21.4% C_2H_2	1975	9.6	1977	1977	—	+ 2	+ 2	—
12. 15.5% CH_4, 84.5% C_2H_2	2275	9.5	2265	2265	—	−10	−10	—

publication [3] to demonstrate more completely the worth of the method.

The observed flame temperatures of the various mixtures, Nos. 1–8, given in Table 1 with various proportions of air, are shown graphically in Figs. 7 to 14, inclusive. Curves for mixtures Nos. 9–12, Table 2, have already been published.[3]

FIG. 7.



Flame temperatures of mixtures of mixed coal gas and air.

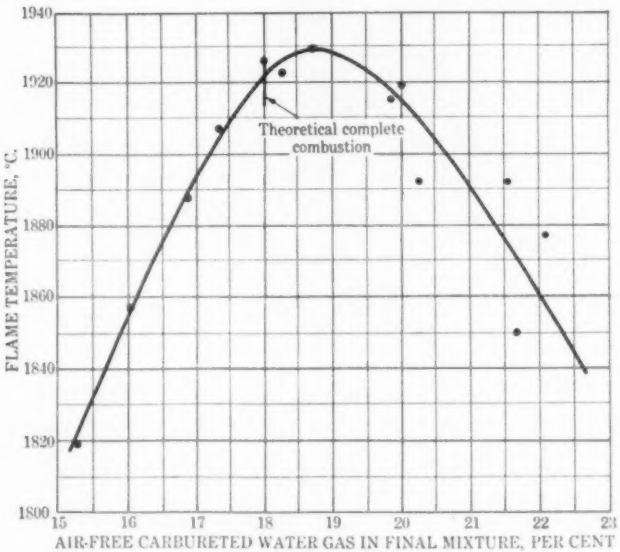
The observed maximum flame temperature of each gas and the percentage of "gas" present in the mixture with air which gives the maximum flame temperature are tabulated in the second and third columns of Table 2.

The calculated maximum flame temperatures and the differences between these and the observed values are also given in Table 2.

Calculation of Flame Temperatures of Mixed Gases.

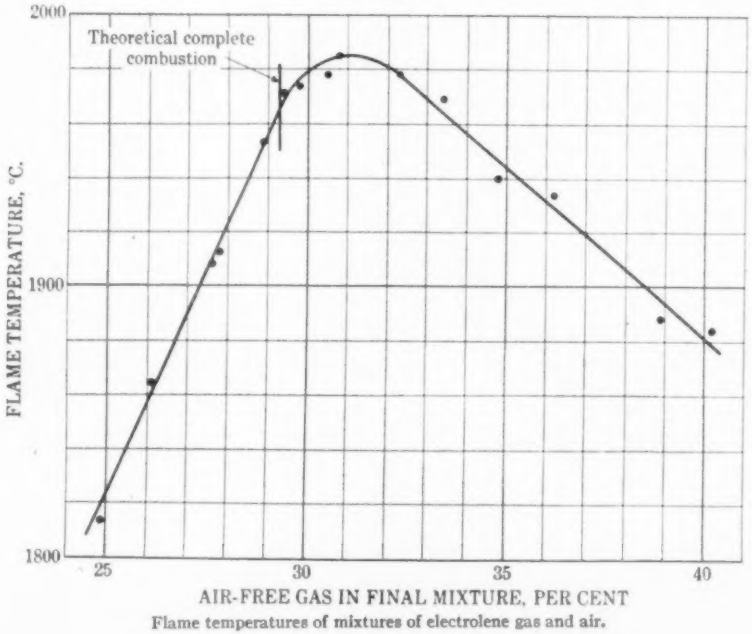
The calculation of the flame temperatures of mixed gases requires the tabulation of the data in such a form that it may be applied to the mixture law originally used by Le Chatelier for the calculation of the limits of inflammability of gas

FIG. 8.



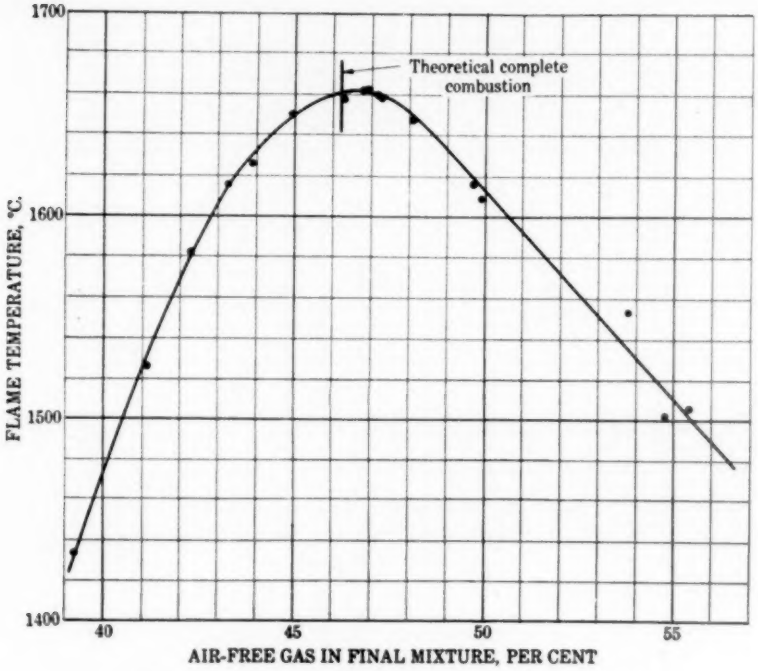
Carbureted water gas.

FIG. 9.



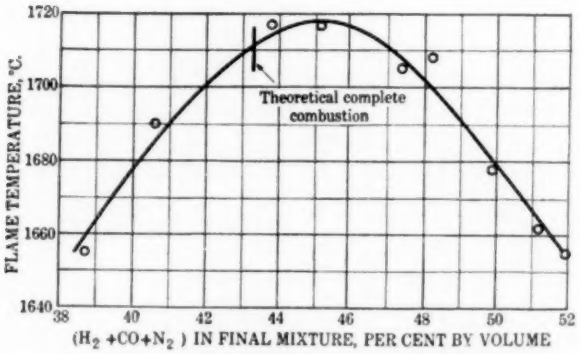
Flame temperatures of mixtures of electrolene gas and air.

FIG. 10.



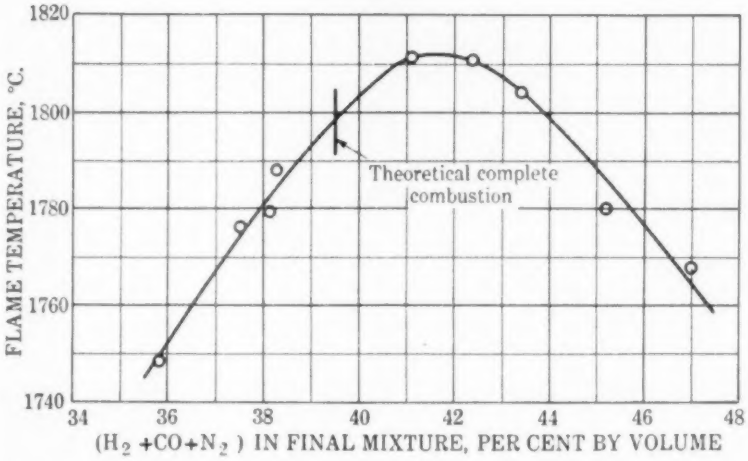
Flame temperatures of mixtures of anthracite producer gas and air.

FIG. 11.



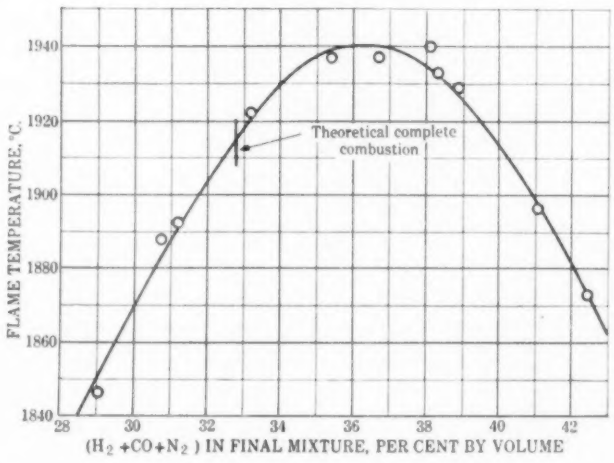
Flame temperatures of $CO-H_2-N_2$ air mixtures. Air-free analysis: H_2 = 22.7 per cent., CO = 31.9 per cent., and N_2 = 45.4 per cent.

FIG. 12.



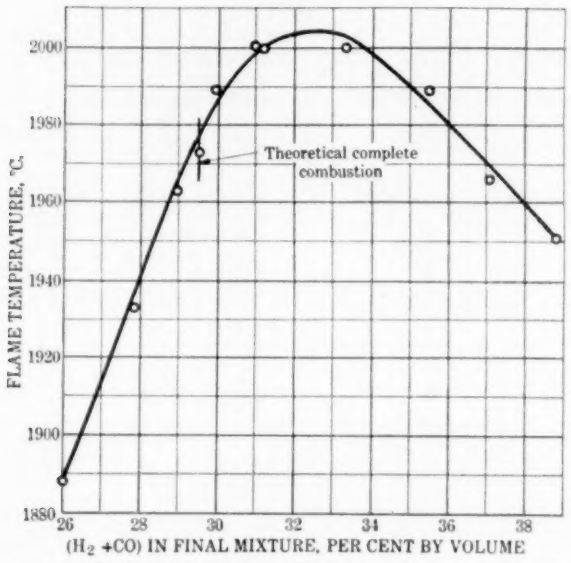
Flame temperatures of $CO-H_2-N_2$ air mixtures. Air-free analysis: H_2 = 27.1 per cent., CO = 37.0 per cent., and N_2 = 35.9 per cent.

FIG. 13.



Flame temperature of $CO-H_2-N_2$ air mixtures. Air free analysis: H_2 = 35.5 per cent., CO = 50.1 per cent., and N_2 = 14.4 per cent.

FIG. 14.



Flame temperatures of CO—H_2 air mixtures. H = 41.5 per cent., and CO = 58.5 per cent.

mixtures containing more than one combustible. The mixture law enables one to calculate the numerical value of any one property of a mixture of substances from the values of that property determined for the individual components of that mixture. By the application of this law the density of a mixture of gases can be derived from the densities of the individual components, and the limits of inflammability of complex gas mixtures can often be accurately calculated if the composition of the mixture and the limits of inflammability of the individual combustible constituents are known. Payman [6] employed the Le Chatelier law to calculate the speed of uniform movement of flame. The authors also used the law for the calculation of the flame temperatures of the binary mixtures, methane-hydrogen and methane-acetylene mixtures, which have been reported in a previous publication.[3]

For this purpose the following equation is employed:

$$T = \frac{aT_a + bT_b + cT_c + \cdots}{a + b + c + \cdots}, \qquad (1)$$

[6] Payman, W. *Jour. Chem. Soc.*, **115**, 1919, p. 1446.

where a, b, $c \cdots$ represent the volume of each combustible plus the proper amount of air required to furnish a maximum flame-temperature mixture for this combustible; T_a, T_b, $T_c \cdots$ are the maximum flame temperatures of each of these component mixtures; and T is the maximum flame temperature of the complex mixture.

The law given above for the determination of maximum flame temperatures has been applied heretofore [3] only to mixtures of combustibles containing no inert gases such as nitrogen and carbon dioxide.

However, the equation may be used in the form described above for the calculation of the maximum flame temperatures of mixed gases containing nitrogen and carbon dioxide if the complex mixture is somewhat arbitrarily dissected into simpler mixtures, each of which contains only one combustible gas and part of, or all of, the nitrogen or carbon dioxide. There are various ways in which a gas mixture may be subdivided into simpler mixtures and the calculated values found will vary somewhat depending upon how this is done. To show how the subdivision is made and its effect on the calculated flame temperatures, the calculation of the mixed coal gas will be given in detail.

In the example to be worked out (Table 3) the illuminants as found by the usual methods of gas analysis consist mainly of ethylene, propylene, butylene, and, at times, small amounts of benzene and acetylene. There is no easy way of determining the composition of the illuminants in gas mixtures. In general, for calculating flame temperatures, the illuminants may be assumed to consist of equal parts of ethylene and propylene without introducing appreciable errors because the maximum flame temperatures of the unsaturated hydrocarbons excluding acetylene are not far apart. Unless the amount of illuminants is greater than 10 per cent. of the total gas, an error of only a few degrees results from the above assumption.

The gas contains 2.4 per cent. of carbon dioxide and 4.2 per cent. of nitrogen. In the first subdivision, the carbon dioxide is combined with the methane and the nitrogen with the carbon monoxide. The gas is thus divided into six simpler components as shown in the first column. In the

TABLE 3.

Tabulation of Data for Calculation of Maximum Flame Temperature of Mixed Coal Gas

Column number.	1.	2.	3.	4.	5.	6.
Composition of gas, air-free analysis, per cent. by volume.	Mixture divided into the following components.	Ratio of inert gases to combustibles.	Volume of each component.	Per cent. of gas giving maximum flame temperature.	Volume component + air.	Maximum flame temp., ° C.
Carbon dioxide 2.4	Ethylene 2.3	0.00	2.3	7.0	32.9	1975
Illuminants 4.5						
Hydrogen 49.8	Propylene 2.2	0.00	2.2	4.6	47.8	1935
Carbon monoxide 11.8						
Methane 25.8	Hydrogen 49.8	0.00	49.8	31.6	157.6	2045
Ethane 1.5						
Nitrogen 4.2	Methane ..... 25.8 Carbon dioxide 2.4	0.09	28.2	10.7	263.5	1829
	Carbon monoxide ..... 11.8 Nitrogen 4.2	0.36	16.0	39.3	40.7	1822
	Ethane 1.5	0.00	1.5	5.8	25.6	1895
Total 100.0	100.0		100.0		568.1	
Or the gases may be combined as follows:						
	Ethylene 2.3	0.00	2.3	7.0	32.9	1975
	Propylene 2.2	0.00	2.2	4.6	47.8	1935
	Hydrogen ..... 49.8 Nitrogen 4.2	0.08	54.0	33.2	162.6	1990
	Carbon monoxide ..... 11.8 Carbon dioxide 2.4	0.20	14.2	37.6	37.8	1800
	Methane 25.8	0.00	25.8	10.0	258.0	1875
	Ethane 1.5	0.00	1.5	5.8	25.6	1895
Total	..... 100.0		100.0		564.7	

second column the ratio of the inerts, nitrogen and carbon dioxide, to the combustibles is given, and in the third column the volume of each component on the basis of 100 volumes of gas. For those combustibles which have no nitrogen or carbon dioxide combined with them, the maximum flame temperatures (column 6) and per cent. of gas giving the maximum flame temperatures (column 4) are taken from Table 4. The data included in this table are derived from previous reports.[2, 3]

TABLE 4.

Maximum Flame Temperatures of Combustible-air Mixtures.

Combustible	Maximum flame temperature, ° C.	Per cent. of gas giving the maximum flame temperature
Acetylene	2325	9.00
Butane	1895	3.25
Iso-butane	1900	3.25
Butylene	1930	3.40
Carbon monoxide	1950	34.00
Ethane	1895	5.80
Ethylene	1975	7.00
Hydrogen	2045	31.60
Methane	1880	10.00
Natural gas—Pittsburgh	1890	8.85
Propane	1925	4.15
Propylene	1935	4.60

The maximum flame temperature value for the methane and carbon dioxide component having a ratio of carbon dioxide to methane of 0.09 is taken from the curve shown in Fig. 4, and the per cent. of gas (methane + carbon dioxide in the final mixture) giving this maximum flame temperature is taken from the other curve in the same Fig. 4. In a similar way the values for the carbon monoxide-nitrogen component are taken from the curves given in Fig. 5. We now have all the information required for the calculation of the flame temperature of the gas.

Column 5 gives the total volume of the component plus the required amount of air. These values are obtained by dividing the volumes given in column 3 by the percentages given under column 4. The sum of these volumes, 568.1, gives the total final volume when 100 volumes of the original mixture is mixed with the proper amount of air to give the maximum flame temperature. When these values are substi-

tuted in equation (1) one obtains the following:

Flame temperature

$$= \frac{32.9\times1975+47.8\times1935+157.6\times2045 \\ +263.5\times1829+40.7\times1822+25.6\times1895}{568.1} = 1907^\circ \text{ C.}$$

Thus the calculated flame temperature is found to be 1907° C.

The coal gas may be subdivided in another way as shown in the second division of Table 3. The values for the ethylene, propylene, methane, and ethane components are taken from Table 4, while the values for the hydrogen-nitrogen component are taken from Fig. 1, and the values for the carbon monoxide-carbon dioxide component from Fig. 6.

Substituting the values given in columns 5 and 6 in equation (1) one obtains:

Flame temperature

$$= \frac{32.9\times1975+47.8\times1935+162.6\times1990 \\ +37.8\times1800+258.0\times1875+25.6\times1895}{564.7} = 1915^\circ \text{ C.}$$

or a flame temperature of 1915° C. Thus it is seen that by combining the nitrogen and carbon dioxide with different combustibles a difference of 8° C. was found. In the case of producer gas in which the amount of nitrogen is much higher, greater differences are found when it is combined in various ways.

Perhaps the most satisfactory way of combining the inert gases with the combustibles is to apportion the nitrogen and carbon dioxide among the three combustibles, hydrogen, methane, and carbon monoxide in the same relative proportions that each combustible is present in the gas. This method was also carried out. The results of all the calculations are given in Table 2.

In this table the observed maximum flame temperatures of the different mixed gases tested are given, and also the per cent. of the gas present which gives the maximum flame temperature. There are also given the highest and lowest values obtained by calculation, and the values obtained when the nitrogen and carbon dioxide are combined with the hydrogen, methane, and carbon monoxide in proportion to the amounts of the latter combustibles present.

The results obtained show that for most of the mixed gases the calculated values agree fairly closely with the observed values. The largest error occurs in the cases of producer gas and carbureted water gas. For these gases the observed and calculated values are about 45° C. apart.

The results of tests made with several special mixtures containing hydrogen, carbon monoxide and nitrogen indicate that these differences may possibly be attributed in part to the presence of larger amounts of nitrogen in the original gas. Also, in the case of carbureted water gas, the presence of large amounts of illuminants may account for the difference found.

The results obtained for the various gases listed in Table 2 warrant the conclusion that by use of the graphs and data given in this report the maximum flame temperatures of industrial gases can be calculated to an accuracy of within 40° to 50° of the actually determined flame temperature. For gases containing small amounts of nitrogen and carbon dioxide (< 10 per cent.) the calculated results should be within 20° C. of the actual determined flame temperature.

ACKNOWLEDGMENTS.

The mixed coal gas, carbureted water gas, electrolene and anthracite producer gas were supplied to the authors through the generous efforts of H. K. Richardson of the Engineering Department of the Westinghouse Lamp Company, Bloomfield, N. J. This company fabricated special tanks for transporting the gases to the Pittsburgh station of the Bureau of Mines. The authors deeply appreciate the time, trouble and expense incurred by this company in providing these gases for tests.

SUMMARY.

The flame temperatures of mixtures of hydrogen, or methane, or carbon monoxide containing various amounts of nitrogen and carbon dioxide, with air, have been determined. The flame temperatures of a number of complex mixtures of combustible gases and industrial gases have also been determined. A method of calculating the maximum flame temperature of any mixed gas is described. Good agreement is found between the calculated and determined temperatures of the gases used in this investigation.

Ice Cream.—DAVID WILBUR HORN (*Am. Jour. Pharm.*, 1932, civ, 721–733) describes the development and present status of the ice cream industry in the United States. This product was first manufactured on a wholesale scale by Jacob Fussell of Baltimore in 1851. A bibliography on ice cream published in 1926 contained 291 pages. The production in Pennsylvania in 1930 was 39,000,000 gallons. The factors which have made possible the rapid growth of the industry have been mechanical refrigeration, homogenization, and pasteurization of the mix preferably at a temperature of 150° F. for 30 minutes. In order to insure maximum cleanliness, ice cream should be sold to the ultimate consumer in an original package. Its bacterial count should be less than 100,000 micro-organisms per gram of ice cream, using agar as the medium and blood heat as the temperature of incubation. The legal standards for ice cream deal chiefly with the butter fat content, and vary with the State. A content of at least 14 per cent. butter fat is required of plain ice cream in interstate commerce.

J. S. H.

Polyhalite as a Source of Potash to Plants.—Polyhalite is a mineral which contains one molecule of potassium sulphate, one molecule of magnesium sulphate, two molecules of calcium sulphate, and two molecules of water. It contains approximately 12 to 16 per cent. of potash, and occurs in deposits in western Texas and New Mexico. G. S. FRAPS (*Texas Agric. Exp. Station Bull.* No. 449, 16 pages, 1932) reports that the solubility of its potash in water depends on the degree of fineness to which the polyhalite is ground. When ground to pass a 10 mesh sieve but not a 20 mesh sieve, 36.8 per cent. of the potash dissolved. When ground to pass a 20 mesh sieve, 73.2 per cent. of the potash dissolved; and the mineral thus ground was suitable for use as a potash fertilizer. In pot experiments with corn and kafir, the potash of the polyhalite had an availability about equal to that of potash in sylvite (potassium chloride).

J. S. H.

DIAGONAL SYMMETRY IN CHLADNI PLATES.

BY

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The complete solution for the nodal lines on a square plate requires both trigonometric and hyperbolic terms; but for high vibrations, the trigonometric terms will give the approximate form of the sand figures. If great accuracy is desired, the hyperbolic terms must be introduced particularly along the edges.[1] The general theorems discussed here will be developed from the simpler trigonometric forms, with the understanding that they are also true for the equations which contain both types of terms.

When the hyperbolic terms are omitted, the plate may be regarded as a square membrane with free edges. The solution for such a membrane is

$$A \cos\frac{m\pi x}{a}\cos\frac{n\pi y}{a} + B\cos\frac{n\pi x}{a}\cos\frac{m\pi y}{a} = 0, \qquad (1)$$

in which m and n are whole numbers, a is the side of the square, A and B are arbitrary numbers. The symmetrical forms are found when $A = B$. If m is odd and n even or vice versa, one diagonal of the square is a nodal line. This is shown by the following examples which are obtained from equation (1). For $m = 1$, $n = 4$, equation (1) reduces to

$$\left(\cos\frac{\pi x}{a} + \cos\frac{\pi y}{a}\right)\left(8\cos^3\frac{\pi x}{a}\cos\frac{\pi y}{a} - 8\cos^2\frac{\pi x}{a}\cos^2\frac{\pi y}{a} + 8\cos\frac{\pi x}{a}\cos^3\frac{\pi y}{a} - 8\cos\frac{\pi x}{a}\cos\frac{\pi y}{a} + 1\right) = 0. \qquad (2)$$

The first factor of this equation represents the diagonal. In the equations below u is written for $\cos \pi x/a$ and v for $\cos \pi y/a$.

[1] *Phil. Mag.*, Vol. XII, Suppl. August 1931, p. 320. *Jour. Franklin Inst.* Vol. 214, No. 2, August 1932, p. 199.

The values of m and n are indicated at the extreme right.

$$(u+v)\left\{\begin{array}{r} 32u^5v - 32u^4v^2 + 32u^3v^3 - 32u^2v^4 \\ + 32uv^5 - 48u^3v + 48u^2v^2 \\ - 48uv^3 + 18uv - 1 \end{array}\right\} = 0, \quad (1, 6)$$

$$(u+v)\{u^2(8v^2-4) - 2uv - 4v^2 + 3\} = 0, \quad (2, 3)$$

$$(u+v)\left\{\begin{array}{r} u^4(32v^2 - 16) - u^3(32v^3 - 16) \\ + u^2(32v^4 - 56v^2 + 20) \\ + u(16v^3 - 10v) - 16v^4 \\ + 20v^2 - 5 \end{array}\right\} = 0, \quad (2, 5)$$

$$(u+v)\left\{\begin{array}{r} u^7(512v^3 - 384v) - u^6(512v^4 \\ - 384v^2) + u^5(512v^5 - 1208v^3 \\ + 768v) - u^4(512v^6 - 1208v^4 \\ + 768v^2) + u^3(512v^7 - 1208v^5 \\ + 1408v^3 - 480v) + u^2(384v^6 \\ - 768v^4 + 352v^2) - u(384v^7 \\ - 768v^5 + 480v^3 + 92v) + 4v^2 - 3 \end{array}\right\} = 0. \quad (3, 8)$$

All of these equations have the factor $(u + v) = 0$ which represents one straight line diagonal. In the experimental production of these lines, it is extremely difficult to keep A exactly equal to B. This causes the diagonal to vary slightly from a straight line (Fig. 1*a* and 1*b*).

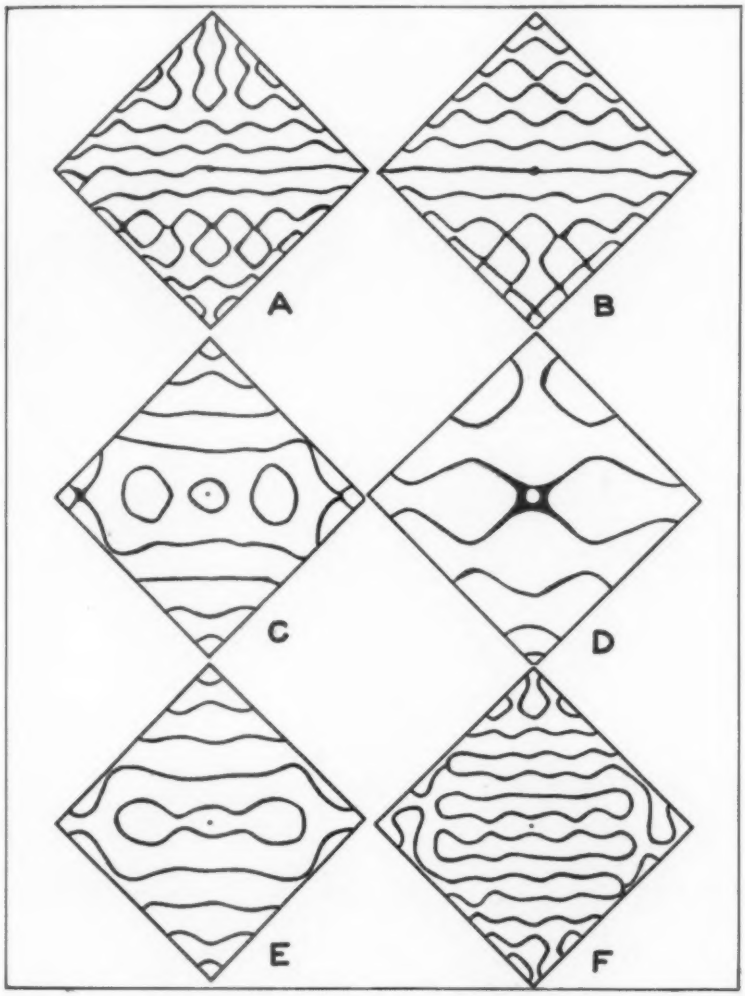
There is also the possibility of a second series of nodal lines in which the diagonal is one of maximum instead of minimum vibration. This can be visualized physically by supposing that the diagonal divides the square into two similar triangles each vibrating in such a way that along the common edge (the diagonal) the vibrations either annul one another to form a nodal line (Fig. 1*a* and 1*b*) or reinforce one another to form a line of maximum vibration (Fig. 1*c*, 1*d*, 1*e*, 1*f*).

As m and n are increased in value, the note rises higher and higher. The nodal lines become greater in number and the resulting figures become more complicated. Such a series is shown in Fig. 2.

The two plates in Fig. 3 have a peculiar symmetry which is not accounted for by the theory given above. If each plate is divided into two equal triangles by a diagonal and one triangle rotated through 180° it will fit over the other triangle.

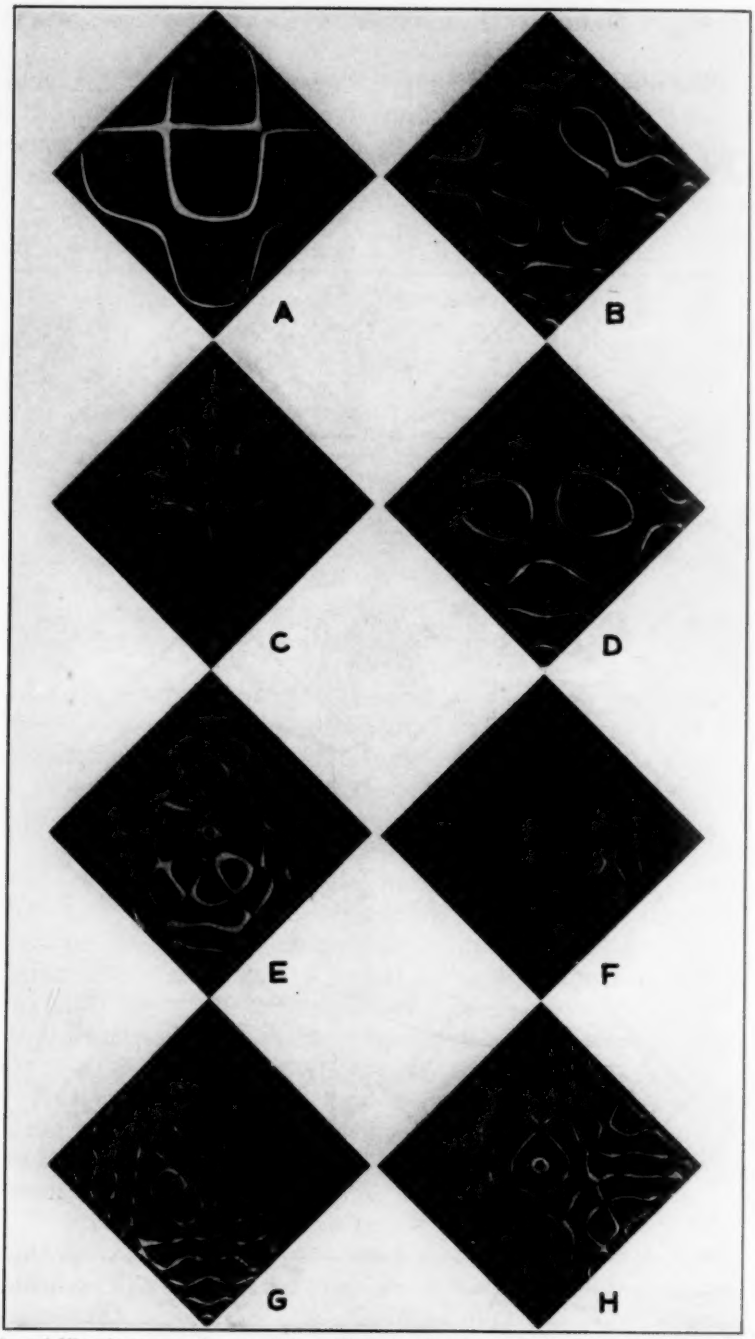
The series of plates in Fig. 4 shows how a slight change in *A* and *B* carries the nodal lines over from symmetry about a single diagonal in Fig. 4*a* to symmetry about both diagonals and both median lines in Fig. 4*f*. So far as the writer knows,

FIG. 1.



These figures are tracings from photographic negatives. In *a* and *b* one diagonal is a nodal line; in *c*, *d*, *e*, and *f* the corresponding diagonal is a line of maximum vibration.

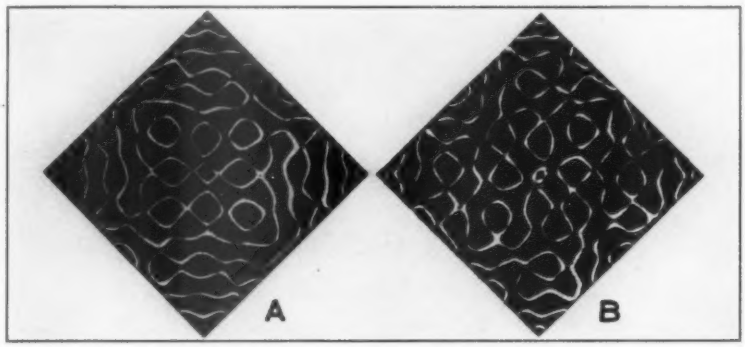
FIG. 2.



The nodal lines increase as the note of the oscillator rises in pitch. The increasing complexity of the figures is shown from *a* to *h*.

a series like this has never been found before experimentally but a theory of such a transformation has been given by Ritz.[2] When m and n are odd, both diagonals are nodal lines as well as the two median lines passing through the center of the square. If m and n are even numbers and multiples of odd and even numbers respectively, the resultant curves have nodal diagonals but the median lines are not nodal. These

FIG. 3.



These nodal patterns show a new type of symmetry.

are illustrated in Fig. 5 with photographic reproductions of the Chladni plate. The theoretical curves plotted from the equation,

$$\cos\frac{m\pi x}{a}\cos\frac{n\pi y}{a} - \cos\frac{n\pi x}{a}\cos\frac{m\pi y}{a} = 0, \qquad (3)$$

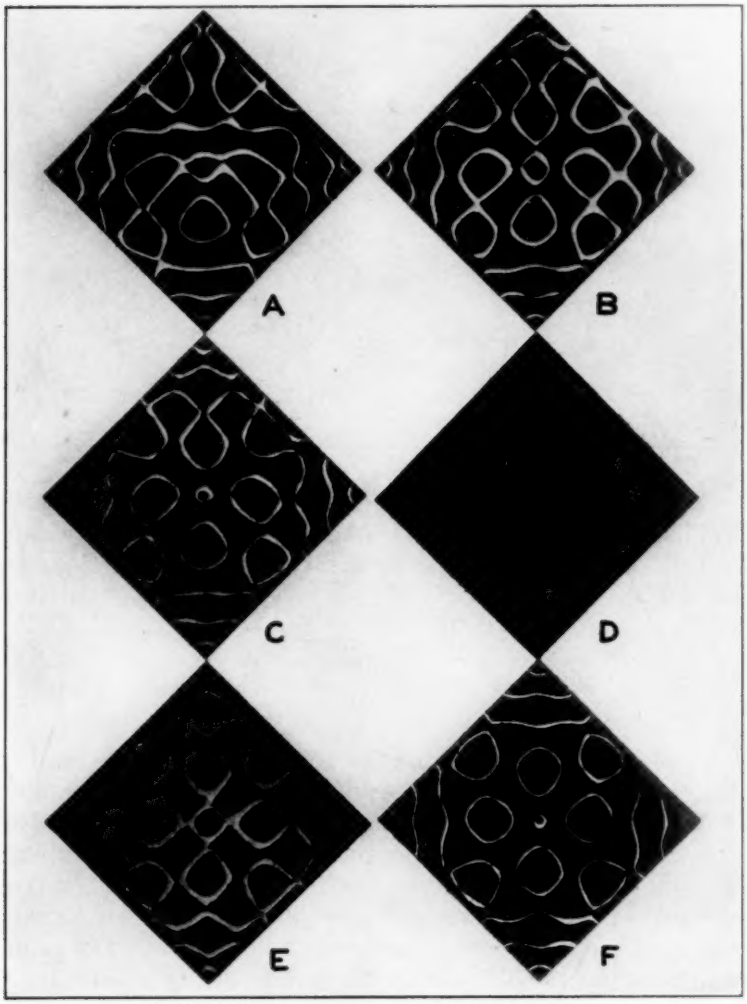
appear in Fig. 6.

In plotting the curves of the Chladni plates one may reduce equation (3) to equations of the form given in equation (2) and those similar to it. These equations are then solved approximately by Horner's method and a sufficient number of points obtained to determine the curve. However, for large values of m and n, when the general shape of each curve is known, it is much simpler to obtain a large number of points by making use of the symmetrical relations in equation (3).

[2] Ritz, *Ann. der. Phy.*, Vol. 28, 1909, page 770.

Thus for the group shown in Fig. 6, the relation $n = m + 2$ is true for each nodal system shown. All the figures are symmetrical about the center and the four corners; the diagonal lines are lines of no vibration. Hence x and y are inter-

FIG. 4.



The nodal pattern assumes many forms for a single note when A and B are varied.

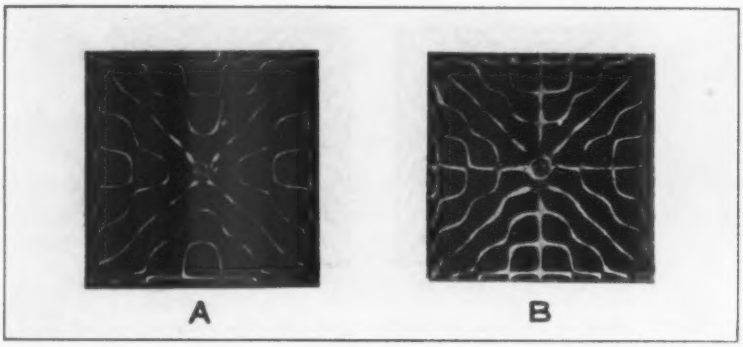
changeable. This means that for any values of x, there are corresponding values of y; more specifically, if

$$x = \frac{N_0 a}{2m},$$

then

$$y = \frac{N_0 a}{2m}, \tag{4}$$

FIG. 5.



These experimental curves should be compared with the theoretical curves given in Fig. 6.

in which N_0 is any odd number between 0 and $2m$. Also if

$$x = \frac{N_0 a}{2n},$$

then

$$y = \frac{N_0 a}{2n}. \tag{5}$$

Similarly if

$$x = \frac{N_0 a}{m+n},$$

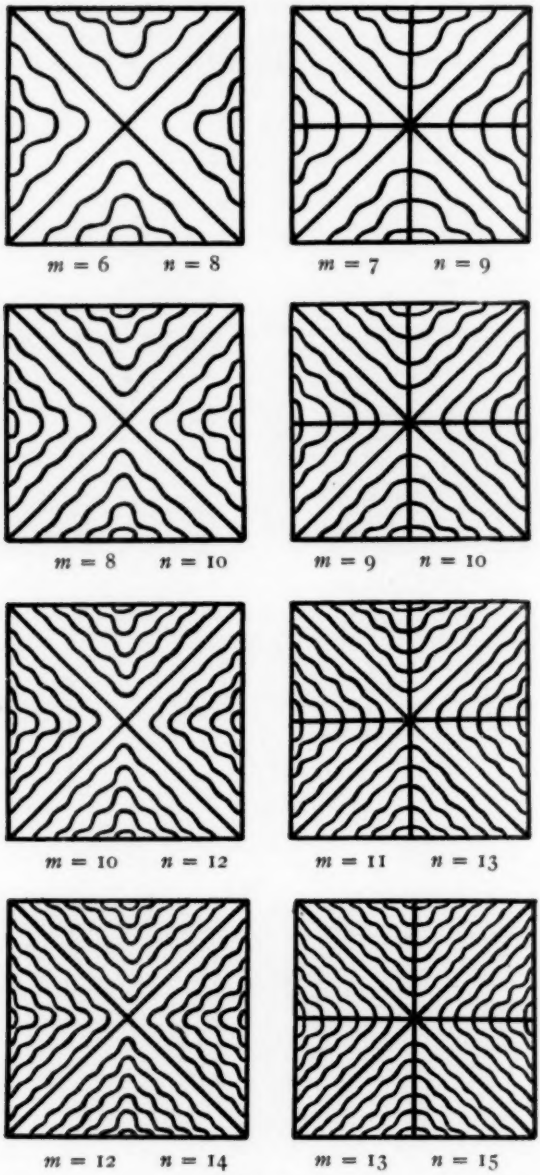
then

$$y = \frac{N_0 a}{m+n}, \tag{6}$$

and if

$$x = \frac{N_e a}{m+n},$$

FIG. 6.



These curves are worked out from equation (1). They are symmetrical about both diagonals and both median lines through the center parallel to the edges. Those on the left have anti-nodal median lines; those on the right have nodal medians.

then

$$y = \frac{N_e a}{m + n}, \tag{7}$$

in which N_e is any even number between 0 and $(m + n)$. For the values $m = 9$, $n = 11$, we obtain from equation (4) the values

$$\frac{x}{a} = \frac{1}{18}, \frac{3}{18}, \frac{5}{18}, \frac{7}{18}, \frac{9}{18}, \frac{11}{18}, \frac{13}{18}, \frac{15}{18}, \frac{17}{18}, \cdots \tag{8}$$

with exactly similar values for y/a. These two sets of values are true in every case, so they give $9 \times 9 = 81$ points on the required curves.

The values of N_0 in equation (5) give

$$\frac{x}{a} = \frac{1}{22}, \frac{3}{22}, \frac{5}{22}, \frac{7}{22}, \cdots \frac{21}{22}$$

or eleven points in all. There are eleven corresponding points for y/a; so that the possible combinations give $11 \times 11 = 121$ points. The odd numbers in (6) give

$$\frac{x}{a} = \frac{1}{20}, \frac{3}{20}, \frac{5}{20}, \frac{7}{20}, \frac{9}{20}, \frac{11}{20}, \frac{13}{20}, \frac{15}{20}, \frac{17}{20}, \frac{19}{20}$$

with ten similar values for y/a. We thus obtain $10 \times 10 = 100$ points from this equation and 100 more from equation (7). This gives a total of 402 points on the curves. The manner in which these points are to be connected together is determined by the family to which the curves belong. This family is found by plotting the first few curves with Horner's method.

The theory given in this article relates every nodal figure on a Chladni plate to a very similar figure upon a supposititious membrane with free edges. The differential equation of the plate is of the fourth degree, while the membrane has a second degree equation. It is thus possible to find an approximate solution for the plate using only trigonometric functions. These theoretical figures can be modified along the edges by the introduction of hyperbolic functions and they will then agree with the experimental curves, the error being approximately two per cent. The sand lines were produced with the valve oscillator described in the papers to which reference is made.

Detection of Adulterants in Lactose.—JOSEPH ROSIN AND F. C. HITCHCOCK (*Jour. Am. Pharm. Asso.*, 1932, xxi, 1282–1286) recommend the following tests. A 5 grain sample of the lactose, ground to 100 mesh or finer, is shaken frequently for 30 minutes with 25 cc. of 70 per cent. (by volume) alcohol. The solution is filtered through a dry filter. A 5 cc. portion of the filtrate is evaporated on a steam bath; the residue is dissolved in 5 cc. of water; this solution is filtered if necessary, mixed in a test tube with 5 cc. of Barfoed solution (a solution of cupric acetate containing free acetic acid), heated in boiling water or actively flowing steam for 3 minutes, and then kept standing at room temperature for 25 minutes. A red precipitate indicates the presence of *dextrose*.

A 10 cc. portion of the original alcoholic filtrate is evaporated on the steam bath; the residue is dissolved in 9 cc. of water; this solution is mixed in a test tube with 0.1 gram of resorcinol and 1 cc. of 25 per cent. hydrochloric acid, and then heated for 8 minutes in boiling water or actively flowing steam. A distinct yellow or reddish yellow color (positive Seliwanoff reaction) indicates the presence of *sucrose*.

One gram of the lactose is dissolved in 10 cc. of water. The solution is boiled for 1 minute, cooled to room temperature and treated with 1 drop of dilute iodine solution (iodine test solution U. S. P. diluted with four times its volume of water). A blue color indicates the presence of *starch*, a red color of *dextrin*, and a violet color a mixture of these two carbohydrates.

J. S. H.

Corn Sirup.—According to A. P. BRYANT AND R. C. JONES (*Ind. and Eng. Chem.*, 1933, xxv, 98–100), corn sirup contains maltose, dextrose, and "noticeable amounts of unfermentable reducing compounds which can hardly be considered as reversion products but rather as reducing dextrins." The total reducing sugar, calculated as dextrose, gives a fairly close measure of the sum of dextrose and maltose. The ratio of dextrose to maltose is approximately 1 : 2 for ordinary conversions, but lies nearer 1 : 1 for higher conversions. For ordinary work and ordinary corn sirup, it is recommended that, of the total reducing sugar as dextrose, one-third be taken as dextrose, and two-thirds as maltose, and that the undetermined carbohydrates be designated dextrins.

J. S. H.

THE CONTROL OF CURRENT ACROSS A SPARK GAP BY MEANS OF AN EXTERNAL MAGNETIC FIELD.

BY

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Mendenhall Laboratory, Ohio State University.

ABSTRACT.

The Control of Current Across a Spark Gap by Means of an External Magnetic Field.—An experimental study was made of the electrical discharge between parallel plates when the pressure between the plates had been reduced to a value slightly less than the critical pressure—i.e. to the condition when a tube begins to harden. Under these conditions the application of a transverse magnetic field will produce a discharge between the electrodes for potentials less than the normal potential required. It is believed that this is due to the lengthening of the path traversed by the ions in crossing the gap. The results obtained may be harmonized by means of the values found by Carr (*Proc. Roy. Soc.* 1903) who made a study of Paschen's Law in the region of critical pressure. In general it is found possible, under the conditions studied, to start a discharge and control the value of the current through a circuit of which the gap is a part by means of varying the magnetic field superposed on the gap and without altering either the impressed E.M.F. or the ohmic resistance of the circuit. This control is effected by altering the effective length of the spark gap in the circuit by means of the external magnetic field.

PROCEDURE AND RESULTS.

In a study of the effect of the magnetic field upon the discharge of electricity through gases it has been found that when an electric current is established across a gap between parallel plates, the superposing of a magnetic field upon the discharge gap may alter the magnitude of the current. Some experiments on this effect were discussed in a recent paper.[1]

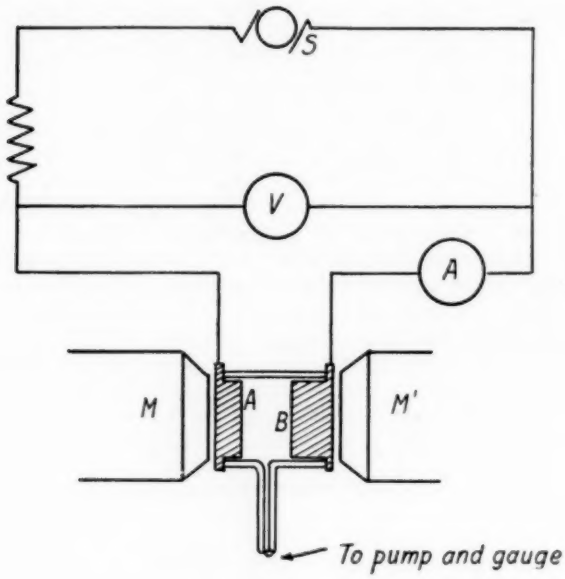
In extending these experiments it has been found, within certain limitations of pressure and gap distance, that a potential which alone will not produce a discharge, may produce one if a suitable magnetic field is applied, and that the strength of the field thus superposed may be used to control the current passing through the circuit of which the gap is a part.

[1] Earhart and Green, *Phil. Mag.*, Jan., 1929, p. 106.

Precht [2] first noted that a magnetic field might alter spark potential. His measurements were made at atmospheric pressure.

The experimental arrangement used in studying this effect is shown in Fig. 1.

FIG. 1.



Parallel electrodes of brass A and B are mounted in a short glass tube which may be partially exhausted, the pressure of the gas between the electrodes being measured with a McLeod gauge. The source S in some cases was a step-up transformer energized by a commercial A.C. 60 cycle current, in other cases a variable high potential D.C. generator was used. A milliammeter (A) served to measure the current passing across the gap while a voltmeter (V) determined the potential drop across the gap. The pole pieces of the electro magnet are indicated by M and M'.

It was thus possible, in a very simple way, to observe the potential difference across and the current passing through

[2] *Precht. Wied. Ann.*, 66, p. 676, 1896.

the gap for any desired pressure and gap distance and to superpose a magnetic field either parallel or at right angles to it. The figure indicates the magnetic field parallel to the gap. In this present experiment the tube was rotated through 90° so that the field was transverse to the gap.

The pressure within the tube was reduced to a value somewhat less than the critical pressure for the gap distance. A potential between A and B was then applied which was somewhat less than that required normally to produce a discharge. The application of a suitable magnetic field will then cause the discharge to occur. Variation in the strength of the applied field could then be used to change the value of the current in the circuit.

Figure 2 is a family of curves which illustrates the character of the changes when the external field is altered. In this case the distance between the electrodes was 1 mm. and the gas was air. The pressure had been reduced until the tube was slightly hard. Under these conditions a potential of 750 volts (without field) gave no discharge. The potential was then reduced somewhat and a magnetic field applied. Each of the curves is identified with a given voltage. The ordinates represent the current across the gap in milliamperes; the applied field in gauss is represented by abscissas.

While it is not possible to offer an ultimate explanation of all the effects, these results may be correlated with a series of experiments by Carr.[3]

These curves are discussed at some length by Sir J. J. Thomson in the "Conduction of Electricity Through Gases," and serve to illustrate and confirm Paschen's Law which connects pressure and distance with spark discharges. Two of Carr's curves taken from Thomson's "Conduction of Electricity Through Gases," pp. 443–445 (2d edition), are here reproduced as Fig. 3.

These curves show the relation between the potential required to produce a discharge in air or in hydrogen when the electrodes are separated 1 mm. or 2 mm., etc., for different pressures.

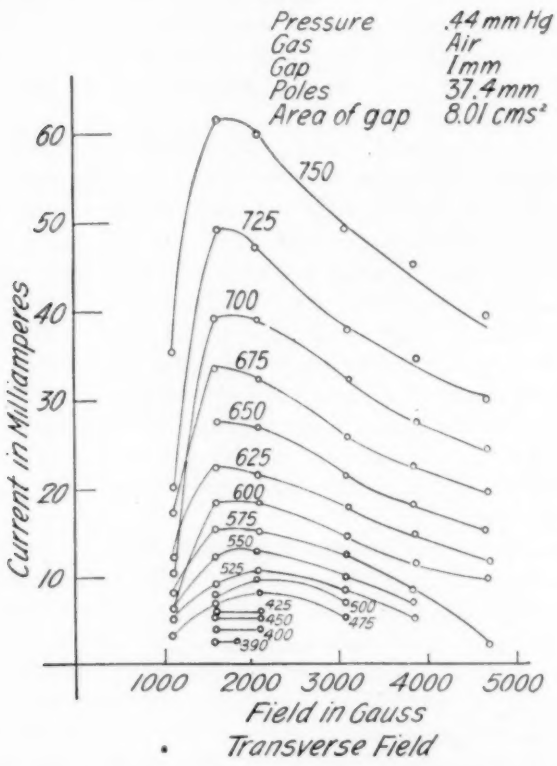
Referring to the curves for air it appears that for a pressure

[3] Carr, *Proc. Roy. Soc.*, 71, p. 374, 1903.

of 2 mm. the potential required to cause a discharge between parallel plates 1 mm. apart is greater than for a gap of 2 mm.

If one selects a point (A') in Fig. 3*a*, corresponding to 1 mm. pressure and 800 volts it is apparent that this would not produce a discharge for a one milliammeter gap but would produce a discharge for a gap less than two milliammeters and would be considerably in excess of the required potential for a 3 mm. gap.

FIG. 2.



Consider now the probable path of the electrons and ions in a discharge between parallel plates both with and without a transverse field. See Fig. 4.

When only the electric field is applied between A and B the ions traverse a path indicated by (*a*). Upon the application of a transverse magnetic field the ions are bent normal to

FIG. 3a.

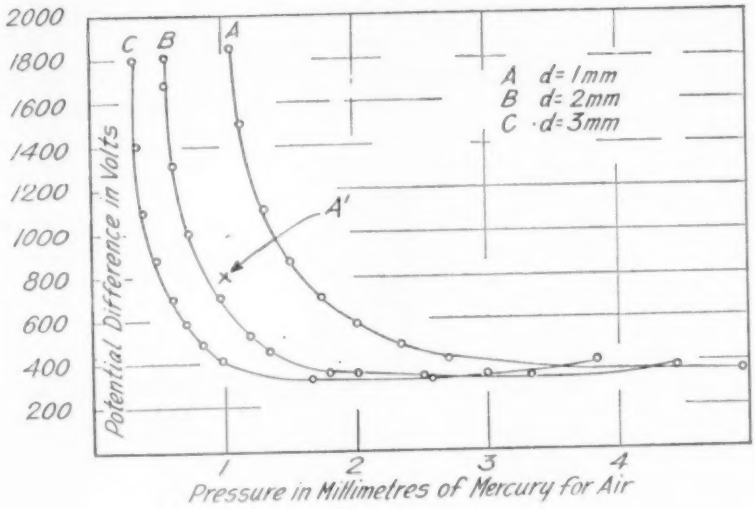
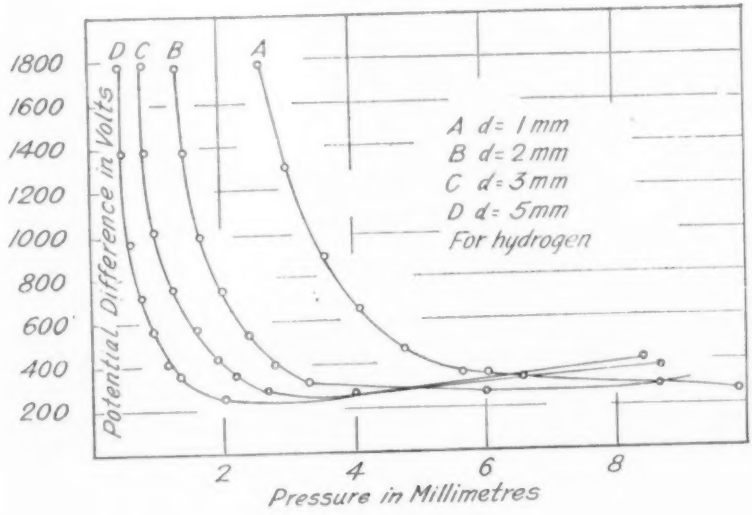

2000
1800
1600
1400
1200
1000
800
600
400
200
Potential Difference in Volts
C
B
A
A d= 1mm
B d= 2mm
C d= 3mm
A'
1
2
3
4
Pressure in Millimetres of Mercury for Air

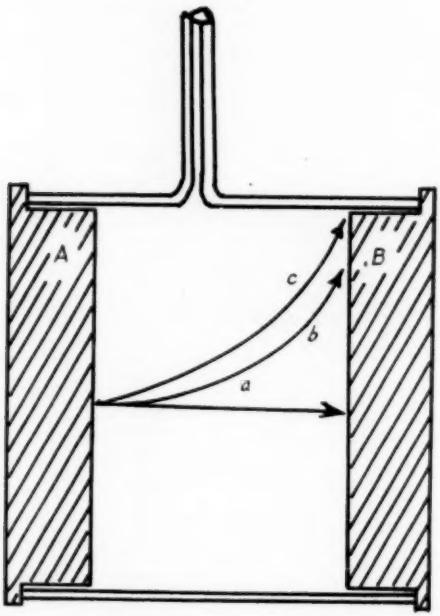
FIG. 3b.


1800
1600
1400
1200
1000
800
600
400
200
Potential Difference in Volts
D
C
B
A
A d= 1 mm
B d= 2 mm
C d= 3 mm
D d= 5mm
For hydrogen
2
4
6
8
Pressure in Millimetres

the lines of magnetic force and traverse the path (*b*), thereby increasing the effective gap distance. With increase in field these are diverted more until they may be turned through the path (*c*) and never reach the opposite electrode.

The family of curves shown in Fig. 2 may be rather definitely correlated with the critical potential curves of Carr.

FIG. 4.

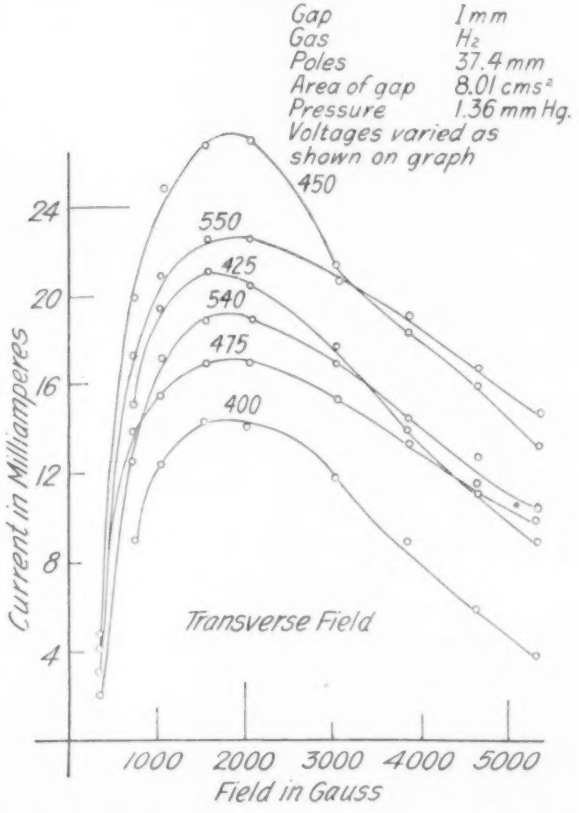


It appears that when the gap is 1 mm. and a potential is applied which does not produce a discharge the effect of the field is to alter the path of the ions so as to increase the effective spark gap, and when the critical distance is reached ionization by collision takes place giving a large glow discharge. When the field is increased further, the effective gap is increased to such an extent that the applied potential is greatly in excess of the one required to start the discharge, and a very rapid increase in current takes place. This continues until a considerable part of the ionized stream is diverted against the walls of the glass tube, and the discharge is extinguished when the entire stream is diverted. Not only

does the theory indicate the diversion of the stream but observation of the glow discharge indicates the same thing.

The maximum current to be obtained depends only upon the size of the electrodes used. In some cases we have used circular electrodes 3.5 cms. in diameter, and have been able to start currents by means of the external field and control

FIG. 5.

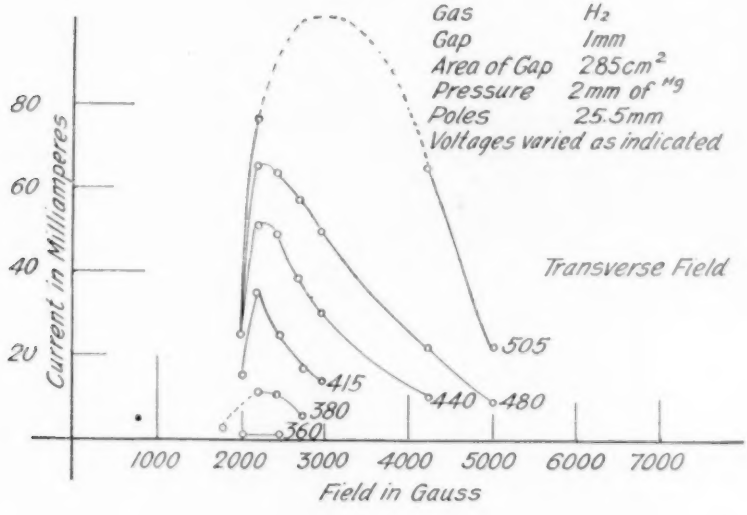


their values between 3 ma. and 250 ma. There is no reason for placing 250 ma. as the limit. Values higher than this were not attempted because of the excessive heating of the electrodes due to ion bombardment.

Figure 5 represents one of the many families of curves taken for hydrogen.

The results represented in Figs. 2 and 5 were obtained from an A.C. source, values being given in virtual volts and amperes. Figure 6 shows a family of curves taken under constant potential conditions. The source at our disposal was a generator with a separate field excitation. With this it was possible to alter potentials from 100 to 2000 volts in steps of approximately 15 volts over the range which was used. The potentials and currents were measured with the ordinary Weston instruments.

FIG. 6.



In general it may be said that below the critical pressure it is possible to start or extinguish a discharge between parallel electrodes by the application of an external magnetic field and that it is possible to regulate the current passing through such a circuit without altering the impressed E.M.F. included in the circuit or its resistance. This control may be very sensitive and is stable. It appears to be due to the control of the effective length of the spark gap.

The results which have been discussed can be accounted for in a rather simple way; however, a case has been observed which does not seem to show complete agreement with this idea.

In this case the tube is operated below the critical potential for the gap used and the potential is elevated so that the discharge starts without the aid of the field.

Then upon regulating the potential until a small current is obtained, say 10 ma., the effect of applying a small field is to decrease the current across the gap; upon increase of field strength the current increases up to its initial value and then follows a curve very similar to the ones usually found as shown by Figs. 2 or 5. In case the start is made with a smaller value of the current, say 5 ma., a weak field decreases and extinguishes the discharge completely, only to have it restored with further increase in field and then to pass through the usual cycle of changes. This does not seem to fit the simple explanation previously suggested and no other explanation is offered.

COLUMBUS, OHIO,
April, 1931.

Maple Products Industry of Pennsylvania.—A. C. MCINTYRE (Pennsylvania State College, School of Agric. Exp. Station, Bull. 280, 47 pages, 1932) has published a monograph on the maple products industry of the State. Since 1900, Pennsylvania has ranked as the fourth state in the Union in the production of maple sugar and syrup. The output in 1920 contained 2,726,000 pounds of sugar and was valued at more than $500,000; the output in 1930 contained 1,172,000 pounds of sugar. About 90 per cent. of the sugar is sold as syrup. Approximately one-third of the product comes from Somerset County. While seven species of maple are native to Pennsylvania, only four species are commonly tapped. The most suitable species for sugar and syrup are the sugar maple (*Acer saccharum*) and the black maple (*Acer nigrum*). A tree may be tapped when it has attained a diameter of 10 or 12 inches at breast height; its age is then from 40 to 45 years. The sap wood is two or three inches wide, and contains from 20 to 30 annual rings. The highest recorded sugar content of the sap is 10.2 per cent. The season of production of syrup and sugar lasts from four to eight weeks. The tree is usually tapped with a 6/16 or 7/16 inch bit; the hole is reamed; and a spout is inserted. The sap is collected in covered buckets. The sap is concentrated to a syrup; during this process, proteins coagulate, and salts deposit; both are removed. The syrup ranges in color from a water white or faint straw to very dark reddish brown, contains at least 65 per cent. of total solids, weighs not less than 11 pounds per gallon, and has a specific gravity of 1.31989 at a temperature of 17.5° C. If too dilute, the syrup may become sour; if too concentrated, it may crystallize. Maple sugar is obtained by further evaporation of the syrup.

J. S. H.

Phospholipins of Wheat.—In the course of a study of the lipins of wheat, B. SULLIVAN AND CLEO NEAR (*Ind. and Eng. Chem.*, 1933, XXV, 100–103) extracted the lipins from wheat, its germ, its bran, and its flour. Each product was extracted with alcohol-ether, ether, acetone, and ethyl acetate. Quantitative determinations were made of the nitrogen content and the phosphorus content of each extract. The ratio of these two elements in each extract was then calculated. When phosphorus was taken as unity, nitrogen always exceeded unity; the N : P ratio varied from 1.5 : 1.0 to 7.4 : 1.0. In lecithin this ratio is 1.0 : 1.0. Therefore, phospholipins other than lecithin are present in wheat and its enumerated products.

J. S. H.

NOTES FROM THE U. S. BUREAU OF STANDARDS.*

MAGNETIC DAMPING FOR LABORATORY BALANCES.

When a magnet is used to damp the oscillations of the beam of a laboratory balance there is obviously some danger that the magnet may introduce errors when magnetic materials are being weighed. Because of recent inquiries, it seemed desirable to obtain some definite data both on this danger and on the time of swing as affected by different degrees of damping. No attempt was made to study the effect of damping on the total time of making a weighing, largely because this depends so much on the personal equation and the kind of work that is being done. Moreover, this question is one that applies equally to any kind of damping.

The balance used had a capacity of 200 g. and was reliable to 0.1 mg. or perhaps somewhat better, and the damping device was one already on the market. The magnet was under the right hand stirrup, about 13 cm above the scale pan.

In studying the possible effect of the magnet on articles weighed, most of the observations were made with either a nickel-steel 20 g. weight or a round bar of steel 5½ cm. long and weighing about 49 g. The presence of the magnet did not introduce any error as great as 0.1 mg. when either object was lying directly on either scale pan, nor when raised 6 cm. above the left pan, nor when the bar was standing on end on the right hand pan. However, when placed with its center 6 cm. above the right pan (i.e., about 7 cm. below the magnet) the 20 g. weight appeared nearly 2 mg. too light, and when the bar was lying in a horizontal position at the same distance below the magnet, it appeared about 3 mg. too light. With other magnets and other arrangements of the balance, these effects might be very different. These results seem of value, however, as giving at least the order of magnitude of effects that may be expected.

* Communicated by the Director.

For loads below 100 g. the balance was "dead-beat," i.e., the pointer would swing out to its final position and stop without further oscillations. For loads of 100 g. or more the pointer would move very slightly once or twice after the first large deflection. The damping was slightly adjustable, but the balance could not be made dead beat at the larger loads, while, even at very small loads, the damping could not be made sufficient to obtain any conspicuous effects of excessive damping.

Damping which is less than dead-beat has two conspicuous disadvantages. The first and most serious of these is that when the balance is nearly dead-beat, the final motions are made so slowly that there is great danger of reading the index before the true equilibrium position has been reached. The other disadvantage is that these final motions require considerable time. For example, under one set of conditions, and for the same amount of deflection, the time required to come to rest was 35 sec. with damping that allowed two or three very slight motions after the first large deflection, but was only 7 sec. with critical damping, i.e., with the minimum damping that would make the balance dead-beat. With a load of 200 g. in each pan, where only the former condition could be obtained with the apparatus available, the time was over one minute.

With any kind of dead-beat damping, it is always necessary to use some deflection from the position when arrested, in order to show that the balance is actually free to swing. This makes it especially important to note that the time which it takes the beam to come to rest depends very much on the size of the angle through which the beam is deflected. For example, for a certain set of conditions it took 20 sec. to come to rest for a small deflection and 40 sec. for a large deflection.

A danger easily overlooked is the possible effect of a magnetic spot in the aluminum damping vane, whether incorporated in the material itself or whether attached to it. Errors from this latter cause were actually experienced in the test. To determine the possible magnitude of such effect a speck of steel weighing about 1 mg. was attached to one edge of the plate about 2 cm. above the magnet. This caused discrepancies up to about 0.3 mg. depending on the amount and direc-

tion of the deflections at which readings were taken, and on the position of the magnet.

There does not seem to be much danger that magnetic particles will ordinarily become attached to the aluminum plate, yet it evidently is possible, and should be guarded against both by careful cleaning and by checking the action of the balance. If the magnet can be moved, the simplest method of checking is probably to determine whether moving the magnet in various directions has any effect on the equilibrium position. There should be no effect.

MEASUREMENTS OF ULTRAVIOLET SOLAR RADIATION ON SEA AND LAND.

With the increasing use of ultraviolet radiation by physicians and the public for healing purposes, there is a demand for information regarding the ultraviolet solar intensity in various localities and under various atmospheric conditions. There is also a demand for simple instruments for measuring these intensities, and in turn there is a demand for methods of calibrating such instruments on a uniform basis.

In Research Paper No. 517, to be published in the January number of the *Bureau of Standards Journal of Research*, a description is given of the calibration of a selective photochemical, ultraviolet dosage intensity meter against a balanced thermocouple and filter radiometer, used as a standard. Data are given of the ultraviolet intensities of solar radiation in various localities at various elevations at several stations in Europe and upon the ocean.

The measurements show a high ultraviolet reflection from clean fresh snow. The ultraviolet intensities over the ocean are not conspicuously higher than at a sea level dust free station on land at the same latitude and the same season of the year.

INTERFERENCE METHOD OF MEASURING THERMAL EXPANSION.

Research Paper No. 515 on the interference method of measuring thermal expansion, which will be published in the January number of the *Bureau of Standards Journal of Research*, has been prepared in response to numerous inquiries

for details of the method developed at the bureau and described in its Scientific Papers Nos. 393 and 485, and several articles in outside publications. It is intended as a manual for the use of those who wish to measure thermal expansions by the interferometric method. As such, a more complete description of the apparatus and methods developed can be included than would be in order in a paper dealing primarily with the results of a particular set of measurements. The apparatus, method of making specimens, forms for taking data and computation of data, each is the subject of a careful exposition. An appendix contains tables and special calculations.

LITHOGRAPHIC PAPERS SENSITIVE TO ATMOSPHERIC HUMIDITY.

Papers used in lithographic printing change in size rapidly with changes in moisture content of the surrounding air, according to results obtained in laboratory studies now in progress in the bureau's paper section. Need of more careful humidity control for press-room air than was heretofore believed necessary is indicated if register difficulties arising from contraction and expansion of the paper are to be avoided.

Lithographic paper is so sensitive to relative humidity that the moisture content changes instantly as the moisture condition of surrounding air varies. All changes in the moisture content of the paper result in dimensional changes of great importance in printing requiring precisely registered impressions. In order to determine the importance of such changes, the bureau is studying 15 different papers in a room where "manufactured weather" permits the control of relative humidity to 1 per cent. and temperature to 1° F. Large sheets of the papers were exposed to successive relative humidities ranging from 28 to 72½ per cent., and the dimensions were carefully measured at each humidity to an accuracy of 0.001 inch by means of a special micrometer rule.

Dimension changes amounting to 0.005 inch or more in 50 inches, sufficient to cause serious difficulties in obtaining close register, were found to result from relative humidity changes of only 4 per cent., these being no greater than variations commonly tolerated in plants having controlled atmosphere. Furthermore, it was found that differences in dimensions re-

sulting from bringing paper to balance with a fixed atmospheric humidity from different directions, that is, bringing the moisture content of a dry paper up or of a moist paper down to balance with the fixed condition, were important. Such differences in dimensions obtained by approaching a humidity from opposite directions were as great as differences caused by 10 per cent. relative humidity variations.

The results are of significance not only to the lithographer, but to the paper manufacturer and to the manufacturer of air conditioning apparatus. Need for increased accuracy in control of atmosphere in printing plants appears to require the concerted attention of lithographers and air conditioning equipment manufacturers in order to minimize waste resulting from distortion of the printing paper. The paper manufacturer can assist by furnishing paper with uniform moisture content nearly in balance with the standard humidity condition maintained in the printing plant.

REACTION BETWEEN DIATOMACEOUS SILICA AND HYDRATED LIME AT ELEVATED TEMPERATURES.

A pozzolana is a substance which, though not necessarily cementitious by itself, possesses constituents that will combine with hydrated lime at ordinary temperatures in the presence of moisture to form stable insoluble compounds of cementitious value. Diatomaceous silica is such a pozzolanic substance. Investigations in England have shown that the pozzolanic activity of diatomaceous silica is increased by heating to about 630° C.

Accordingly, a mixture of domestic diatomaceous silica and hydrated lime (high calcium) was prepared which contained approximately 25 per cent. SiO_2 and 75 per cent. CaO figured on the non-volatile basis. The powdered material was mixed with a little water, molded into bars, and heated in an electric resistance furnace. Free lime determinations were made on separate batches obtained by heating for one hour at different temperatures. Sufficient water was then added to each batch to react with the free CaO to convert it into $Ca(OH)_2$, and each batch was then aged for a week in a closed vessel to permit the CaO to become hydrated. This

partially hydrated material was then ground in a ball mill so that approximately 95 per cent. passed a No. 200 sieve. Briquets were then made which contained 1 part of this ground material to 3 parts of standard Ottawa sand and sufficient water to affect the desired consistency (½ inch slump with a 2 by 4 inch cylinder). The briquets were stored for seven days in air saturated with water and maintained at 21° C. They were then removed from the molds and stored in water for 21 days before breaking.

The following table shows the results obtained:

Temperature of Burning Mixture. ° C.	Tensile Strength of Briquets—28 days. lbs./in.²
600	95
700	115
800	135
1000	210

It can thus be seen that upon heating together diatomaceous silica and hydrated lime a product results which has hydraulic properties. If the material is heated at higher temperatures crystalline calcium silicates are formed.

CLAY IN CONCRETE.

The effects of clay admixtures on the compressive strength, permeability and durability of concrete have been investigated by the National Bureau of Standards with the coöperation of Hugh L. Cooper and Company, Inc., of New York City.

Concretes of three different proportions were tested. The first contained no clay, the proportions being fixed by the following conditions: (1) the bulk volume of the compacted sand was 15 per cent. greater than the voids in the coarse aggregates, (2) the concrete contained five bags of cement per cubic yard, and (3) the consistency was such that a man walking in a large mass of concrete would sink at least three inches and not more than eight inches. The other two concretes were mixed to the same consistency as the first (based on the penetration test) and were of the same proportions except that in one, clay was substituted for 10 per cent. of the volume of the cement and in the other, clay was substituted for 7½ per cent. of the volume of the sand. The proportions by weight of the three concretes were as follows:

Concrete.	Proportions by Weight.				
	Cement.	Water.	Clay.	Sand.	Crushed Rock.
I.....	1	0.71	0.00	2.22	4.77
II.....	1	.81	.08	2.46	5.30
III.....	1	.74	.11	2.05	4.77

Three complete sets of specimens were made of each type of concrete, using three different brands of cements. In addition, three complete sets of those containing clay were made, each set with a different kind of clay, which made a total of 21 mixtures.

Specimens of each mixture were made for testing in compression at the ages of 7 and 28 days; 3, 6, and 9 months; and 1, 2, and 3 years. Absorption and permeability test specimens were prepared for testing first at age 3 months and then retesting at the ages of 6 and 9 months and 1, 2, and 3 years. All specimens were kept in damp storage at approximately 70° F. for 28 days and thereafter some were stored outdoors and an equal number were subjected to freezing and thawing.

The replacement of 7½ per cent. of the volume of the sand by an equal volume of clay increased the compressive strength in various percentages from 1 to 37 per cent. At nine months the permeability was decreased; later it was increased both actually and relative to that of the plain concrete without clay. It should be noted, however, that of the concretes were practically impermeable in these tests.

The substitution of clay for 10 per cent. of the volume of the cement, except for the first two or three months in the case of the ordinary Portland cement concrete, caused a decrease in strength of 0 to 10 per cent. The very slight permeability was not appreciably changed.

The replacement of 7½ per cent. of the sand in one case and 10 per cent. of the cement in the other by equal volumes of clay slightly increased the absorption for specimens stored outdoors, but did not appreciably change that of specimens frozen and thawed.

Four hundred cycles of freezing in air and thawing in water did no apparent injury to the concrete kept continually damp.

The concrete that was dried out after 40, 100, 150, and 200

cycles of freezing in air and thawing in water disintegrated within the range of 85 to 400 cycles.

The difference in absorption, permeability and resistance to freezing and thawing between concretes containing and not containing clay were small.

A report of the investigation will be published as Research Paper No. 529 in the February issue of the *Bureau of Standards Journal of Research.*

MUFFLERS FOR AIRPLANE ENGINES.

For the past four years the Aeronautics Branch of the Department of Commerce, through its research division at the bureau, has been conducting an investigation on the possibility of developing practical methods of reducing the noise in airplanes. The results of various phases of the work have been published previously. The latest work has dealt with mufflers for reducing the noise of the engine exhaust.

In response to an invitation for the public to coöperate in the study of mufflers seven mufflers were received for test. To these were added three experimental mufflers designed at the bureau. Measurements of the reduction in noise and the reduction in engine power resulting from the various mufflers were made at the engine testing laboratory in Arlington, Virginia.

A 180-horsepower, V-type, water-cooled Hispano-Suiza engine was connected to an hydraulic dynamometer which served for measurement of the engine power. The propeller was purposely omitted so as to make the effect of the mufflers more easily measurable. A centrifugal blower driven by an electric motor provided a blast of air to simulate the slipstream. The air from the blower was directed over the mufflers and thus the mufflers received the cooling effect of the slipstream.

The sound measuring equipment consisted of a calibrated condenser microphone, an attenuator box, an amplifier, and an a.c. voltmeter of the full-wave copper oxide rectifier type. Five band pass filters transmitting frequencies of 0–250, 250–500, 500–1500, 1500–3000, and 3000-infinity cycles were used to study the distribution of sound energy with frequency.

The effective attenuation of the filters outside their nominal range was about 35 decibels. The working range of the apparatus was from 30 to 10,000 cycles.

The load imposed by the hydraulic brake was adjusted to give a speed of approximately 1400 r.p.m. with the engine throttle set in the wide open position. Corrections were applied for air temperature and barometric pressure, and the engine power computed for exactly 1400 r.p.m., assuming constant torque.

Sound measurements were made at six stations at different distances from the engine. The microphone was held in the hand about four feet above the ground and pointed toward the engine. Readings were taken without a filter and with each filter in turn. With the aid of the calibration data the sound intensity at each measuring station was computed from the voltmeter readings for that station.

The power output of the engine and the noise level were determined for the following basic reference conditions: (*a*) all manifolds removed and the exhaust gases escaping to the atmosphere directly from the exhaust ports of the engine, (*b*) the side manifold attached, (*c*) the side manifolds coupled together by means of a siamese connection. (*d*) the exhaust gases piped from the siamese connection to an underground muffler.

The above conditions were used for determining the reduction in horsepower and noise that should be credited to the various mufflers. Thus, when one muffler was used it was attached to the siamese fitting and the effect was noted by comparison of the results with the results for the siamese condition; when two mufflers were used one was attached to each of the side manifolds and the results compared with the results for the side manifolds; when mufflers were attached directly to the exhaust ports with no manifolding the results were compared with the results for the open ports.

The results of the sound measurements were expressed in decibels above a reference intensity of 10^{-14} watts per cm.^{2} per sec.

The results for the underground muffler, which eliminated practically all of the exhaust noise, show that the noise level from valve clatter and other mechanical sources is compara-

tively high for any station near the engine, namely, 70 to 90 decibels. The intensity of the engine noise in the different frequency bands is remarkably uniform, the variation from the mean value being about five decibels.

The noise level for the open port condition is about 98 decibels for stations near the engine and about 83 decibels for stations about 80 feet from the engine. The intensity of the original noise in the various frequency bands is fairly uniform, the variation from the mean value being about ten decibels. Obviously the exhaust noise does not have a dominant frequency although the intensity is greater in the high frequencies and there is a noticeable minimum in the 250–500 cycle band.

The experiments with mufflers indicate that the noise level of the exhaust and engine in the absence of the propeller can be reduced to about 80 decibels near the engine and to about 65 decibels at a distance of about 80 feet. The use of mufflers means a reduction of about 1.5 per cent. in engine power and a slight decrease in pay load as compared to an engine with manifolding.

It is not profitable to use a muffler unless the propeller tip speeds are sufficiently low to make the noise of the propeller less than that due to the unmuffled engine.

JET-PROPULSION.

In its broadest sense, jet-propulsion is the name for that type of propulsion which is characteristic of prime movers designed to work in a fluid medium such as air or water, or in empty space. In a fluid the jet may be composed of the medium itself set in motion by some mechanical device such as a screw. In empty space the fluid must come from within the vehicle itself. At one extreme we find the air screw and water screw, and at the other the rocket. Usage has eliminated air and water screws from the class of jet-propellers, and has restricted that term to propellers in which the jet issues from nozzles. In particular, the term jet-propulsion refers to propulsion by means of high-speed jets of relatively small diameter forced from nozzles by high pressure. Jet-propellers in this restricted sense have a low propulsive effi-

ciency as compared to the screw, because of the smaller amount of fluid from which propulsion is derived. To offset this is the simplicity that results from creating the jet by means of fluid under pressure, rather than by means of a moving mechanical mechanism external to the vehicle.

Probably because of its simplicity the jet-propeller has always been regarded as an attractive type of prime mover. Numerous attempts have been made to use it, and all have failed to become practically useful; at low propelling speeds, because of the inherently low efficiency of the jet as compared to the screw propeller, and at high speeds, where the screw propeller is not so keen a competitor, and in empty space, because travel is not yet possible under these conditions. In applying the jet to propulsion in air, some experimenters have attempted to augment the jet with air from the surroundings, thereby shifting it into the class of larger jets (such as those given by the air screw) and giving it a corresponding increase in efficiency. Molet and others have attempted to use something like an injector, employing curved guide rings or venturi tubes concentric with the jet. Maurice Roy proposed mounting nozzles on the tips of a screw propeller. R. H. Goddard has tried to use the jet to drive air screws until a high speed at a high altitude is reached, and then to remove the screws and allow the jet to work alone. None of these schemes has as yet become practical. Furthermore, the last two tend to destroy the original simplicity.

The problem of augmentation was attacked at the Bureau of Standards at the request and with the financial assistance of the National Advisory Committee for Aeronautics. The purpose of the work was to determine from tests with compressed air whether the jet could be made a competitor of the air screw, using simple augmenting devices. Models of airships were tested, in one case with the jet issuing straight backward from the tail, in another with the jet spreading radially as a sheet over the nose, and in a third case with the jet spreading radially into the surrounding air from the tail. The first was found to be as good as, but no better than, the free jet (i.e., the presence of the model did not affect the thrust), and the other two far inferior. A large variety of guide rings and venturis, such as those tried by Molet, were tested. The

best of the jets augmented in this way was only ten per cent. better than the free jet. Nozzles which had the appearance of hollow truncated cones with the jet in the form of a cylindrical shell issuing from the end of smaller circumference were tried as a modification of the guide ring and venturi scheme. The best result was a seven per cent. increase over the corresponding free-jet reaction. An interesting experiment was tried in which a jet in the form of a sheet was made to issue nearly normal to the chord from the trailing edge of an airfoil. In a wind the jet induced such motions in the passing air as resulted in large lifts. It was impossible to throw a component of this lift into the wind by setting the airfoil at a negative angle of attack.

It is concluded that to augment the jet sufficiently to make it practical is a difficult if not impossible task. Taking the present results as typical, it seems that the jet will probably never find use at low speeds unless such lighter, more concentrated, and cheaper fuels than those now in use become available as will enable the free jet, in spite of its low efficiency, to compete with the screw.

NOTES FROM THE BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE.

COMPARISON OF THE MASSES OF He AND H^1 ON A MASS-SPECTROGRAPH.[1]

BY

K. T. BAINBRIDGE,

Bartol Research Foundation of the Franklin Institute.

ABSTRACT.

The ratio of the masses of He : H^1 was measured by comparison of He^{++} with H_2^{1+} on fourteen spectra, and the measurements give He : H^1 = 3.971283 ± 0.000042. If He = 4.00216 ± 0.00013 on the O^{16} scale as given by Aston, then H^1 = 1.007775 ± 0.000035 in excellent agreement with the value 1.00778 reported by Aston.

A method is suggested for the determination of the mass of H^2 in terms of He and C.

Aston [2] has pointed out the difficulties and advantages encountered in comparing the mass of helium with that of the light hydrogen isotope by measurement of the separation of the components of the $He^{++} - H_2^{1+}$ doublet, and has recommended this method as the most direct and trustworthy for the determination of the He : H^1 ratio, so important in nuclear physics.

EXPERIMENTAL PROCEDURE.

Fortunately with the present mass spectrograph [3,4] it is not essential to obtain traces of identical density. Owing to the difficulty in securing He^{++} on the first trial spectra photographed it was found necessary, however, to decrease the amount of hydrogen present in the discharge. "Pure" helium, which evidently contained some hydrogen, was mixed

[1] This paper was presented before the American Physical Society at the Atlantic City meeting, December 28, 1932, and was published in *The Physical Review*, January 15, 1933.

[2] F. W. Aston, *Nature*, **130**, 21 (1932), Isotopes, p. 70, second edition.

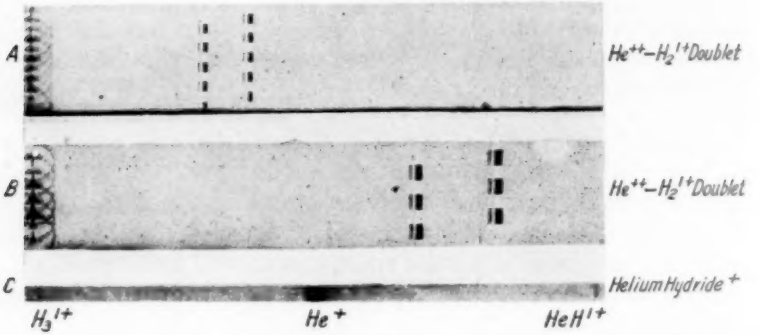
[3] K. T. Bainbridge, *Phys. Rev.*, **42**, 7 (1932).

[4] K. T. Bainbridge, *Phys. Rev.*, **40**, 130 (1932), and a paper shortly to appear in the Journal of the Franklin Institute.

with oxygen, and before admission to the discharge tube, the mixture was passed over hot tantalum filaments and then over spongy palladium at the temperature of liquid air. The tantalum was used to absorb any hydrogen present which did not combine with the oxygen in the presence of the hot filamets. It was hoped that the greater part of any remaining hydrogen would be adsorbed by the palladium.

Figure 1, spectra A and B, is a contact print of sixteen spectra of $He^{++} - H_2^{1+}$. The spectra were taken with one minute exposures. As may be noted H_2^{1+} is still present in abundance compared with the less easily obtainable He^{++}. The H_2^1 had its source either in a minute amount of water released from the walls and glass of the discharge tube even

FIG. 1



after the most careful baking and washing out, or in the failure of the tantalum and palladium to clean up the hydrogen present initially in the helium.

The spectra were measured directly on a Gaertner comparator. The separation of $He^{++} - H_2^{1+}$ was also measured for all the spectra on a Koch-Goos recording microphotometer at a ratio of record distance to plate distance of approximately 40 to 1. The densitometer records also served to detect any possible distortion of the traces which might result from overlapping or might be produced by the Eberhard and Kostinsky effects.[5] As the traces were well separated no distortion was

[5] F. E. Ross, *Astrophys. J.*, **53**, 349 (1921). "Photography as a Scientific Implement," pages 200, 201.

present. The measurements by both methods were in excellent agreement with a difference in the averages in measuring the separation of the traces of one part in 2000, equivalent to 0.000007 mass units.[6]

The separation of the $He^{++} - H_2^{1+}$ doublets for fourteen spectra is given in Table I in mass units referred for convenience to $H^1 = 1.007780$.

TABLE I.

Mass Separation of $He^{++} - H_2^{1+}$ Doublets on $H^1 = 1.007780$ Scale.

Spectra[7]		Spectra	
A3	0.014408	A10	0.014372
4	464	B1	500
5	435	2	660
6	544	3	566
7	546	4	363
8	530	5	566
9	408	6	223

The average mass separation $H_2^{1+} - He^{++}$ is 0.014470 $\pm$ 0.000020. The dispersion of the plate in the region of the doublets was determined from spectra of carbon and its hydrides. The dispersion was determined to better than one part in 2000 so that if the measurement of the separation of the doublets could be made without error it would be possible to determine, with an accuracy of one part in 280,000 the mass of He^{++} referred to H_2^{1+}. Any error introduced by the uncertainty in the dispersion would be less than 0.000007 mass units. When the uncertainty in the dispersion is included the probable error becomes $\pm$ 0.000021 mass units.

[6] The densitometer measurements were taken as the most reliable because, although the comparator measurements were more consistent internally, there is a possibility of systematic subjective influences in the comparator measurements. With a comparator the cross hair is moved to what is estimated as the center of a line, an operation which may be performed with a high degree of accuracy on single lines. If one other line is viewed in the microscope at the same time, as in the case of measuring doublets, it is not known whether or not the influence of that adjacent line interferes with the bisection of the line being measured. If an effect exists it is believed that it would tend to make the measured separation less than the actual separation by a small amount.

[7] The top spectrum of A is number 10. Numbers 1 and 2 were not measured. The top spectrum of B is number 6. The reproduction is $\frac{2}{3}$ natural size.

RESULTS.

The ratio of the mass of He to the mass of H^1 = 3.971283 ± 0.000042. If He = 4.00216 ± 0.00013 on the O^{16} scale, as given by Aston,[8,9] then by these measurements H^1 = 1.007775 ± 0.000035, a value in excellent agreement with Aston's which had been obtained on a different mass-spectrograph by a different method. Finally for convenience in comparison with figures already familiar, if H^1 is taken as 1.007780, He = 4.002180 ± 0.000042 referred to H^1 alone.

The present measurement of the He : H ratio makes it improbable that Aston's He : H ratio might be in error by 0.9×10^{-4} and indirectly that Aston's determination of the mass of He by means of the ratios $He^+ : O^{++} :: C^{++} : C^+$ could be in error by 1.8×10^{-4}.[10]

H^1 may conveniently be used as a common reference mass for the comparison of values of the mass of H^2 derived from different experiments. The mass-spectrograph value [3] of the mass of H^2 is raised and the band spectrum value [11] is decreased by one part in 2×10^5 when referred to the present value of H^1.

A SUGGESTED NEW METHOD FOR THE MEASUREMENT OF THE MASS OF H^2 WITH RESPECT TO He AND C.

Spectrum [12] C, Fig. 1, shows the presence of HeH^{1+} and suggests that when more concentrated H^2 is available the mass of H^2 may be measured by comparison of HeH^{2+} with C^{++}. The two traces would differ in mass by approximately one

[8] F. W. Aston, *Proc. Roy. Soc.*, **115A**, 487 (1927).

[9] The probable errors of Aston's mass determinations are taken as one-third of the published limits of error unless otherwise noted. This convention has been used before for the purposes of calculation by J. Chadwick, J. E. R. Constable and E. C. Pollard, *Proc. Roy. Soc.*, **130**, 480 (1931). K. Bainbridge, reference 3, page 5. J. Chadwick has also used the factor ¼, *Proc. Roy. Soc.*, **136**, 702 (1932).

[10] Reference 3, page 10.

[11] J. D. Hardy, E. F. Barker and D. M. Dennison, *Phys. Rev.*, **42**, 279 (1932).

[12] Spectrum C provides an interesting example of the linearity of the mass-scale and an alternative method of measuring He : H. The ratio He : H may be measured from the reproduction to an accuracy of about one part in 500 if the positions of the lines H_3^{1+}, He^+ and HeH^{1+} are measured to 0.1 mm. In general the dimensions of the velox prints from which the reproductions are made are some 1 per cent. less in linear dimensions than the original spectrum plates. In this case the shrinkage was uniform.

part in 430, a difference greater than the proportional separation of O^{16} and CH_4, a doublet which has been measured by Aston.[7]

The author is pleased to acknowledge the support of Dr. W. F. G. Swann in this work and wishes to thank Professor John A. Miller and the members of the staff of the Swarthmore College Observatory for their generous permission to use their measuring instruments.

Sugar Industry Abroad.—The following facts have been gleaned from the account of a tour made by C. A. BROWNE (*Ind. and Eng. Chem.*, 1933, xxv, 61–68) during 1929 and 1930. Beet sugar is produced in England, France, Spain, and Czechoslovakia. In England, there are 18 beet sugar factories, as well as an experimental plant at Eynsham near Oxford. The beet sugar region of France was in the war zone, but is now thoroughly and completely restored. The Sugar Institute of Prague in Czechoslovakia contains a collection of 350 substances which have been isolated from the sugar beet.

The sugar cane was introduced into the region of the Mediterranean by the Arabs during the seventh century of the Christian Era. It is cultivated in Palestine, Egypt, and Spain. The annual production of cane sugar in Egypt is 150,000 tons. To produce one ton of sugar requires 3600 tons of water for irrigation of the plantations. The native population of Egypt and the Soudan demand hard conical loaf sugar; each cone weighs about 1800 grams. Five sugar factories and one refinery were in operation in Egypt. A sucrose normal weight of 20 grams and saccharimeters with a corresponding scale were in use there.

J. S. H.

THE FRANKLIN INSTITUTE.

ANNUAL MEETING, WEDNESDAY, JANUARY 18, 1933.

The annual meeting of the Institute was called to order at eight-twenty-three p.m. by the President, Mr. Nathan Hayward.

The President announced that the meeting of the evening was a joint meeting of the Institute and the Philadelphia Section of the American Society of Refrigerating Engineers, and expressed the pleasure of the Institute in having this organization meet with us.

The minutes of the December meeting were approved as printed in the January number of the JOURNAL of the Institute.

The President called upon the Secretary of the Institute for a report on elections. That officer read a report of the election prepared by the Tellers and stated that, the election having been held in accordance with our by-laws, the following gentlemen were duly elected for the offices and terms indicated:

President (To serve one year)	Nathan Hayward
Vice-Presidents (To serve one year)	Henry Howson
	C. C. Tutwiler
	Walton Forstall
	W. Chattin Wetherill
Treasurer (To serve one year)	Benjamin Franklin
Managers (To serve three years)	E. G. Budd
	Walton Clark
	C. A. Hall
	G. A. Hoadley
	A. A. Kent
	G. W. Pepper
	J. S. Rogers
	H. Smith

On behalf of the Institute the Secretary expressed deep appreciation for the labors of the Tellers. They were: Mr. W. N. Jennings, Mr. G. S. Cullen and Dr. T. K. Cleveland.

The President then called upon the Secretary for the report of the activities of the past year. The report is printed herewith.

There was no further business so the President presented the speaker of the evening, Mr. Clarence Birdseye. Mr. Birdseye spoke very extensively and interestingly of the various elements which go to make successful quick freezing of food supplies. He pointed out the differences among foods and indicated the changing treatments applied to different substances.

The meeting closed with a considerable amount of discussion and an expression of appreciation of Mr. Birdseye's talk by the President of the Institute.

HOWARD MCCLENAHAN,
Secretary.

REPORT OF THE FRANKLIN INSTITUTE—FOR THE YEAR 1932.

TO THE PRESIDENT AND MEMBERS OF THE FRANKLIN INSTITUTE:

In accordance with our usual custom, the following resumé of the activities of The Franklin Institute is presented for your information at this, the annual meeting of this society. I have the feeling that, due to the kindly interest of the Press, the life of the Institute has been more or less of an open book during the last year, especially insofar as the new building is concerned.

I should like, however, to call your attention to the fact that, while the new building is by far the most important work which we have under consideration at the present time, and with the new building we mean also the new industrial and technological museum, it is not the only direction in which the affairs of the Institute are progressing.

The Library continues to show a steady and gratifying growth, both by acquisitions through gifts and by expansion through the additions of important works chosen by our librarian and our committee in charge of the library.

The library now contains one hundred thousand and sixty-five volumes, thirty-three thousand, two hundred and sixty-six pamphlets, and four thousand, eight hundred and fifty maps, charts and photographs.

Both the character and the reputation of our library are shown by the following pleasant incident which happened to the Secretary of the Institute. A letter came from a Congressman from North Carolina, who wrote something as follows: "I have had occasion to refer to an article in a journal (giving title and name of periodical). I went to the Bureau of Standards, naturally thinking I should find it there. They did not have the work. I then went to the Bureau of Chemistry of the Department of Agriculture. I was informed that that book was not possessed by the Bureau but the speaker was of the opinion that it could probably be found at The Franklin Institute in Philadelphia. So I am writing," continued the Congressman, "to ask if you have the work and if you will have the article in question photostated for me?"

Within a half hour the article was on the way to the photostat room; in the later afternoon the photostat was mailed to North Carolina.

This is by no means an isolated incident. Our library is especially strong in complete sets of periodicals which render such an incident liable to happen frequently.

More and more people are discovering The Franklin Institute as an agent for the dissemination of knowledge through our lectures. Efforts are made to bring to the Institute men of high caliber, who can present authoritatively to the Institute subjects of technical and scientific interest. It has been found that the audiences which fill our Hall are easily capable of understanding and appreciating these talks. Our lecturers are informed that they need not 'talk down' to their auditors, for the latter are accustomed and able to comprehend technical talks.

During the past year, the attendance at the lectures has been very satisfactory both in numbers and in the caliber of the auditors.

The lectures have in almost all cases been printed in subsequent numbers of the JOURNAL of the Institute and have contributed notably to the maintenance of the high quality of that periodical.

The Christmas Week Lectures for Young People, on the James Mapes Dodge Foundation, were given as usual during the week immediately after Christmas. They were on the very timely subject of aviation and were delivered by Mr. Elisha N. Fales, an aeronautical engineer who was well informed and very capable of presenting this interesting subject to an equally interesting group of young people. The lectures were accompanied by a wealth of experiments which entertained as well as instructed.

The membership of the Institute has rather satisfactorily held up, although there has been little if any increase. The number of withdrawals has been less than was feared because of the general condition of affairs. It is with great regret that I have to report that during the past year we lost many distinguished and long time members by death. Among those who were connected with The Franklin Institute for a long period of years, and who were known to many of you here, were General J. J. Carty, an Honor Member of the Institute, Mr. Hugo Bilgram, an active and long time member of the Committee on Science and the Arts, Dr. Monroe B. Snyder, who often led the discussions after our meetings in this Hall, Mr. W. R. Webster, a noted metallurgist, Dr. George F. Kunz of New York, the gem expert, and Mr. S. T. Bodine and Mr. Tinius Olsen, all devoted members of this society.

In order that the Institute shall be able to carry on the Benjamin Franklin Memorial and the new museum, it will be necessary to increase notably the membership of all classes. To this end the whole problem of membership, attendance interest, etc., is being studied by the Committee on Membership. That Committee hopes to report its conclusions very definitely to the Institute at an early meeting.

The Committee on Science and the Arts, the group composed of members of the Institute which labors untiringly in examining all sorts of cases with the idea of awarding medals for meritorious work, has completed sixteen cases. Four cases were dismissed without prejudice and thirty-six cases involving new subjects were considered. The annual Medal Day exercises, which bring to Philadelphia so many scientists and distinguished people from other walks of life, are the direct results of the activities of this Committee.

To all concerned, the reputation gained by, and the research work carried on at, the Bartol Research Foundation Laboratories are a source of lasting satisfaction. Under the brilliant leadership of Dr. Swann, the laboratory has become one of the outstanding small laboratories of the United States, where researches of the highest order are carried to definite conclusions. During the last year a great quantity of work of high value has been carried on in the realm of cosmic radiations and in the determinations of multiple atomic weights by the study of isotopes. The April monthly meeting is made notable by the report for the year of the Director of the Laboratory, Dr. W. F. G. Swann.

A trip down the Parkway shows more clearly than words the progress which has been made in the erection of the new home of the Institute in the Benjamin Franklin Memorial. A considerable part of the building is under roof, while the balance will be in a few weeks.

The scientific staff is successfully occupied with the collection and preparation of exhibits. If the museum were to be opened tomorrow we should be able to make a striking display of interesting and instructive things. In transporta-

tion, mechanisms, in railroad engineering, in radiations and photoelectricity, and in electrical communications, splendid collections have been made. The superb Fels Planetarium together with the ten inch refracting telescope and the twenty-four inch reflector assure an astronomical section which will be a source of lasting pleasure to all interested in astronomical knowledge. The section devoted to the development of the steam engine will contain about thirty engines of widely varying types. The display devoted to aviation cannot fail to be most impressive. It will include much specially made apparatus illustrative of the principles of aviation, a large collection of aeroplane engines, scale models of all different types of airplanes—and will house permanently the airplane in which was made the first solo flight to Europe by a woman. These are but samples of the exhibits which are being prepared for the enjoyment of the public.

I should be most remiss if I should fail to acknowledge the fine cooperation extended to us by institutions and individuals in our efforts to get together the exhibits alluded to. The University of Pennsylvania, the Pennsylvania Art Museum, Wagner Institute, the Philadelphia Board of Public Education, Dickinson College, many industrial and manufacturing concerns, and scores upon scores of individuals have shown an eager willingness to aid us in our collections. We shall owe much of the success of our exhibits when we open the museum towards the end of this year, to these proven friends.

On February 13, 1883, Mr. Alfred Rigling entered into the service of The Franklin Institute and from that day to this has been a faithful and valuable member of this organization. The Institute is very happy to devote the meeting of February fifteenth to a celebration in honor of Mr. Rigling, at which time he will recount many reminiscences of fifty years. We would strongly urge all friends of Mr. Rigling and of The Franklin Institute to be present at that meeting.

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of Stated Meeting held Wednesday, January 11, 1933.)

HALL OF THE COMMITTEE,
PHILADELPHIA, JANUARY 11, 1933.

MR. E. L. CLARK *in the Chair.*

The following reports were presented for final action:

No. 2921: McAdam's Work in Corrosion Fatigue.

This report recommended the award of the Edward Longstreth Medal to Doctor Dunlap Jamison McAdam, Jr., of the Department of Metallurgy, Bureau of Standards, Washington, D. C., "In consideration of the fact that Doctor McAdam has provided information that satisfactorily explains certain structural failures, has developed formulæ and diagrams to illustrate the complex relationship of the influences of stress on corrosion, and has done more than anyone else to establish the fundamental principles of corrosion fatigue, coupled with the fact that the information provided has already been usefully applied and should have wide future practical application."

No. 2962
No. 2963
} The Standing Committee on The Franklin Medal presented its report for final action making the following recommendations:

"That two Franklin Medals be awarded in 1933—one to

"DOCTOR ORVILLE WRIGHT, of Dayton, Ohio, 'In recognition of the valuable investigations carried out by him and his brother, Wilbur, from which they obtained the first reliable scientific data concerning the principles of flight and the design of aeroplanes, upon which they constructed the first heavier-than-air machine which flew by its own power under human control';

"And the other to

"DOCTOR PAUL SABATIER, of Toulouse, France, 'In recognition of his numerous and fruitful contributions to the general field of chemistry and especially to organic chemistry, in which he discovered the catalytic activity of finely divided common metals and devised methods for their use in science and industry.'"

The following reports were presented for first reading:

No. 2910: Work in Theoretical Thermodynamics.

No. 2937: Locomotive Booster.

GEO. A. HOADLEY,
Secretary to Committee.

MEMBERSHIP NOTES.

(Stated Meeting Board of Managers, January 18, 1933.)

CHANGES OF ADDRESS.

MR. WALTER H. DILKS, 1631 Land Title Building, Philadelphia, Pa.
MR. GLENDON J. DUNLAP, 101 Ridgefield Street, Hartford, Connecticut.
DR. H. RUSSELL FISHER, 243 West Gorgas Lane, Chestnut Hill, Philadelphia, Pa.
MR. G. E. KINNIER, 614 Fourteenth Avenue, Bethlehem, Pa.
MR. ALEXANDER E. REOCH, RCA Victor Company, Inc., Camden, New Jersey.
MR. FRANK L. WRIGHT, Metallurgist, Norma Hoffmann Bearing Corporation, Stamford, Connecticut.

NECROLOGY.

Mr. S. D. Benoliel, Philadelphia, Pa.
Brigadier General J. J. Carty, Winter Park, Florida.
Mr. Y. Motynago, Tokyo, Japan.
Mr. W. R. Webster, Philadelphia, Pa.

LIBRARY NOTES.

RECENT ADDITIONS.

American Annual of Photography, 1933. Volume 47. 1932.
American Society for Testing Materials. Proceedings of the Thirty-fifth Annual Meeting. Volume 32, parts 1–2. Two volumes. 1932.
BROWN, BASIL. Astronomical Atlases, Maps and Charts: an Historical and General Guide. 1932.

BRUHAT, GEORGES. Le Soleil. 1931.

Chemisch-Technische Reichsanstalt. Jahresbericht VIII, 1929. 1930.

EVANS, ARTHUR F. The History of the Oil Engine. A Review in Detail of the Development of the Oil Engine from the Year 1680 to the Beginning of the Year 1930. No date.

Faraday's Diary: Being the Various Philosophical Notes of Experimental Investigation Made by Michael Faraday during the Years 1820–1862 and Bequeathed by him to the Royal Institution of Great Britain. Now, by Order of the Managers, Printed and Published for the First Time, under the Editorial Supervision of Thomas Martin, with a Foreword by Sir William Bragg. Volumes 1–2. 1932.

FLEISCHMANN, W. Lehrbuch der Milchwirtschaft. Siebente Auflage, vollständig neubearbeitet von H. Weigmann. 1932.

FRIEND, J. NEWTON, editor. A Text-Book of Inorganic Chemistry. Volume 7, Part 2: Sulphur, Selenium, and Tellurium. 1931.

GILL, AUGUSTUS H. Automobile Gasoline: its Dangers and Tests. 1923.

HACKNEY, NORMAN. The Quantitative Analysis of Inorganic Materials. 1930.

HARDY, ARTHUR C., AND FRED H. PERRIN. The Principles of Optics. First edition. 1932.

HEDGES, ERNEST S. Protective Films on Metals. 1932.

HURST, J. E. Melting Iron in the Cupola. Modern Practice in the Construction, Maintenance and Operation of the Cupola in the Gray Iron Foundry. 1929.

JEFFREYS, HAROLD. Cartesian Tensors. 1931.

JONES, E. TAYLOR. Induction Coil Theory and Applications. 1932.

KIMBALL, ARTHUR L. Vibration Prevention in Engineering. 1932.

KLEIN, G., editor. Handbuch der Pflanzenanalyse. Dritter Band, erste und zweite Hälfte. Spezielle Analyse, zweiter Teil. 1932.

MARCELIN, ANDRÉ. Solutions Superficielles: Fluides à Deux Dimensions et Stratifications Monomoléculaires. 1931.

MEISSNER, W. WALTER. Chemischer Handatlas. Anorganische Chemie unter besonderer Berücksichtigung von Atomphysik und Atomchemie. 1931.

MIDGLEY, EBER. Technical Terms in the Textile Trade: a Dictionary of Yarns, Cloths, Makes, Weaves and Terms for Spinners, Manufacturers, Merchants, Distributors, etc. Volumes 1–2. 1931–1932.

NEEDHAM, C. H. LATIMER. Sailplanes: their Design, Construction and Pilotage. 1932.

NIERENSTEIN, M. Incunabula of Tannin Chemistry. A collection of some early papers on the chemistry of the tannins, reproduced in facsimile and published with annotations. 1932.

PARKS, GEORGE SUTTON, AND HUGH MARTIN HUFFMANN. The Free Energies of Some Organic Compounds. 1932.

Pennsylvania Water Resources Service. Stream Flow Records for the Water Year October 1, 1927 to September 30, 1928. No date.

PERKIN, W. H., AND E. STANLEY KIPPING. Organic Chemistry. Entirely new edition. 1922.

POHL, R. W. Physical Principles of Electricity and Magnetism. Authorized translation by Winifred M. Deans. 1930.

POHL, R. W. Physical Principles of Mechanics and Acoustics. Authorized translation by Winifred M. Deans. 1932.

Royal Society of London. Philosophical Transactions. Series B. Volume 221. 1932.

SAHA, M. N., AND B. N. SRIVASTAVA. A Text Book of Heat; Including Kinetic Theory of Matter, Thermodynamics, Statistical Mechanics, and Theories of Thermal Ionisation. 1931.

SILBERBERG, L. Luftbehandlung in Industrie- und Gewerbebetrieben. Be- und Entfeuchten, Heizen und Kühlen. 1932.

SMITH, LLOYD EDWIN. The Geographical Publishing Company's Commercial Atlas of the World. Featuring New 1930 Census. Edited by Frederick K. Branom. 1931.

Thomas' Register of American Manufacturers 1932–1933. Twenty-third edition. 1932.

THOMSON, L. M. MILNE-. Die elliptischen Funktionen von Jacobi. 1931.

TURNBULL, H. W., AND A. C. AITKEN. An Introduction to the Theory of Canonical Matrices. 1932.

VAN VLECK, J. H. The Theory of Electric and Magnetic Susceptibilities. 1932.

Western Gas, Publishers. The Handbook of Butane-Propane Gases. First edition. Arranged and edited by George H. Finley. 1932.

WHITE, J. H. The History of the Phlogiston Theory. 1932.

BOOK REVIEWS.

THE PRINCIPLES OF OPTICS. By Arthur C. Hardy, M. A., Associate Professor of Optics and Photography, Massachusetts Institute of Technology and Fred H. Perrin, S. M. Instructor in Physics, Massachusetts Institute of Technology. xiii–632 pages, tables, illustrations, 15 x 23 cms., cloth. New York and London, McGraw-Hill Book Company, Inc., 1932. Price $6.00.

Whether a student is seeking comprehensive knowledge or is aiming to qualify in a special topic, he must first make a substantial general survey of the subject. The present volume more than meets those objects. It provides a solid foundation for those who intend to select optics as a career and at the same time furnishes an adequate exposition of the subject for those who intend to specialize in other branches of optics or engineering. The work includes what is often termed "geometrical optics" and "physical optics," the design of optical instruments and data of importance in their manufacture.

The geometrical theory of image formation is covered in the five chapters that follow an introductory chapter. In that section the discussion of the cardinal points of thick lenses and the limitation of rays in lens-systems by apertures are given remarkably full consideration and analysis. Lens aberrations which follow are treated at even greater length, an unusual and probably unique feature in a book of this kind. The seventh chapter on the resolving power of optical instruments as influenced by diffraction is a more or less transitional topic between those that precede it and those which follow. The next seven chapters include the properties of light-radiation and light-sources, the various detectors of radiation, such as the eye, the photographic plate, the photoelectric cell, and the

measurement of light and color. As regards the photographic plate as a detector, few books, except special treatises, contain such a lucid summary of sensitometry.

The next four chapters on the properties of optical materials and the construction and testing of optical parts is an unusual and valuable addition rarely found in a general treatise. The remainder of the book deals primarily with optical instruments and the principles underlying their design, of which the final chapters are devoted to spectroscopes, interferometers and polarizing apparatus. While the authors have not always adhered to rigorous proofs which are extremely involved and may be found elsewhere, they believe this is more than compensated by the emphasis which is placed upon the principles themselves and the manner in which they are applied.

The work is a remarkably complete concise account of optical principles and of modern practice in their application presented in an attractive form.

L. E. P.

U. S. DEPARTMENT OF COMMERCE, NATIONAL COMMITTEE ON WOOD UTILIZATION, CHEMICAL UTILIZATION OF WOOD. By Henry K. Benson, Twenty-second Report of the National Committee on Wood Utilization, 151 pages, illustrations, tables, 15 × 23 cms. Washington, Government Printing Office, 1932, price fifteen cents.

"Chemical Utilization of Wood" would make an excellent subject for an American Chemical Society Monograph and one of no mean proportions at that. For the present, the above title signifies the Twenty-second Report of the National Committee on Wood Utilization. The author, Henry K. Benson, is Chairman, Division of Chemistry and Chemical Technology, National Research Council. As might be supposed, a report of this nature usually recognizes certain limits in respect to size which is more or less governed by the amount of time its writer deems advisable to spend upon it. Needless to say, the field has been well covered and the report resolves itself into a clear, concise, well and interestingly written summary. Each chapter ends with a list of literature cited and a carefully chosen array of selected references so that the reader may readily extend his reading research upon any topics of special interest.

A very nice arrangement of the subject matter has been made. Beginning with an opening chapter on wood as a product of plant growth, its physical properties and chemical composition are dealt with in turn. In respect to the latter topic, wood is not all or practically all cellulose as we sometimes think. If wood contains sixty per cent. cellulose it is doing well. It also contains about fifteen per cent. hemicellulose and twenty-five to thirty per cent. lignin, not to mention other substances in lesser quantities such as fats, resins, terpene oils, tannins, dyestuffs, mineral constituents, starch, sugar, and alkaloids.

Wood prepared by mechanical means only may be in the form of sawdust, wood flour or mechanical pulp. The applications are varied and numerous. Other utilizable forms of wood may be prepared by adding preservatives against decay, impregnating with flame-retarding substances; exploding the fibers or chemically digesting them for the preparation of wall or insulating board; making veneer of paper thinness.

In the preparation of cellulose from wood the processing generally is chemical in nature and such that will dissolve away the undesired constituents like the

hemicelluloses, lignins and resins. The chapter on "Chemical Wood Pulp" pays particular attention to the sulphite, soda and sulphate processes of preparing cellulose and the chief cellulose products; paper, rayon, smokeless powder, lacquers and plastics.

Wood distillation is still an industry of considerable size and results in such important products as rosin, turpentine, pine oil, acetic acid, methyl alcohol acetone, tar and charcoal. The leaching and extraction of certain types of wood provide tannins for the tanning of hides, dyes for cloth, and from western larch: mucic and oxalic acids. A chapter on "Carbohydrates from Wood" makes special mention of maple sugar, gum arabic, the transformation of wood into sugar and the preparation of ethyl (grain) alcohol from sawdust. The utilization of sulphite waste liquor has claimed the attention of many engineers and its possibilities as a cheap source of raw materials has warranted a separate chapter in this report.

A listing of the various Wood Research Laboratories throughout the world is an indication that there is still much to be found out about wood and apparently the author is assured of a steady job in keeping abreast with all the new developments that must emanate from these institutions.

T. K. CLEVELAND.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

Report No. 446, Airfoil Section Characteristics as Affected by Protuberances, by Eastman N. Jacobs, 18 pages, illustrations, 23 × 29 cms. Washington, Superintendent of Documents, 1932. Price ten cents.

The drag and interference caused by protuberances from the surface of an airfoil have been determined in the N. A. C. A. variable-density wind tunnel at a Reynolds Number of approximately 3,100,000. The effects of variations of the fore-and-aft position, height, and shape of the protuberance were measured by determining how the airfoil section characteristics were affected by the addition of the various protuberances extending along the entire span of the airfoil. The results provide fundamental data on which to base the prediction of the effects of actual short-span protuberances. The data may also be applied to the design of air brakes and spoilers.

RABBINICAL MATHEMATICS AND ASTRONOMY, by W. M. Feldman, 232 pages, illustrations, 8vo. London, Cailingold, 1931. Price $2.50.

The fact of the matter is that all of the mathematics of the "Talmud" is primarily mensuration and refers principally to problems in land surveying, and in astronomy, to the computation of the calendar.

The Hebrew Calendar is based, may I say, primarily on the lunar month and the computations have to do with the holidays for which the date is otherwise fixed in the Biblical text. Had the calendar been based exclusively on the lunar month, there would have been no problems whatever in connection therewith. The real difficulty which had to be solved mathematically was the adjustment of the lunar calendar with the solar system. It was this which raised the whole problem of intercalation. In the "Talmud" itself, methods of computation of the dates are nowhere given, but only the results are set down.

Dr. W. M. Feldman, a practicing physician of Plaistow, England, who says of himself that he is "no Talmudic Scholar, no Practical Astronomer and no Expert Mathematician," is sufficiently proficient in all of these to be able, in the first instance, to read understandingly a complicated and much involved text which, although largely Hebrew, has suffered a strong Chaldean infusion and has freely adapted Latin and Greek words, and in the next place, to apply modern mathematical methods to check the problems worked out by the ancient Rabbis, with the result that he practically confirms the original results.

How these results were originally determined, there is no evidence in the text, but, undoubtedly, it was done sufficiently well to stand the application of the test of modern celestial mechanics, the methods of which, at the time, had theretofore never been employed for that purpose.

In the section on Mathematics, the value of "pi" is given therein as "3." Whether or not this value was used because it was easier of application and it didn't seem to matter a whole lot in the cases wherein it was employed, whether this or a value in excess of this was used, we have no way of determining, but the time of which we are writing was several centuries after Archimedes had determined this same value to be 22/7ths, which is correct to two places of decimals. It is interesting to note, in this connection, that Rabbi Nathan, author of the Forty-nine Middot in the second century, gives the relationship of $3\frac{1}{7}$ to 1, between the circumference and the diameter of the circle.

One of the problems given in the body of the work on Mathematics is interesting and instructive. The method of measuring over a hill is outlined. On the principle that all of the surveying which they did had to do with agriculture, this is easily understandable. We know, even if it is nowhere stated, that it is impossible to grow more plants on a slope than can be grown on the projection of that slope.

In order to be able to measure the slope in terms of its projection, what we do today is to measure the distance between plumblines. In the book in question, one is directed to use a chain of a given length, and a rather short chain at that. This chain the forward chainman holds with his feet and the rear chainman holds against his stomach. It is seen that with a comparatively short chain, it should thus be possible to measure over quite a steep hill.

Other subjects treated are the determination of the length of the permissible Sabbath Day's journey which, by the way, for obvious purposes, no Philadelphia lawyer could ever interpret to mean more things and to mean more varying distances than the ancient Rabbis have done.

The silence of the "Talmud" in regard to the methods by which the Rabbis arrived at their astronomical conclusions was, undoubtedly, for the purpose of keeping this knowledge within the circles of the ruling families, because thereby they were in a position to dictate the religious life of the people.

The book is unique and to those who are interested in antiquarian subjects, it is worthy of a place in their libraries, if only to express admiration for a professional man, undoubtedly a busy one, who uses his spare time for the purpose of making these things understandable to the laity.

SOLOMON M. SWAAB.

AN INTRODUCTION TO PHYSICAL SCIENCE. By Carl W. Miller, Ph.D., Associate Professor of Physics in Brown University. xii–403 pages, illustrations, 15 × 23 cms., cloth. New York, John Wiley & Sons, Inc., 1932. Price $3.00.

A student who is fortunate enough to have qualified to enter a university science course is rarely devoid of a general idea of the phenomena of physics. There may be amazing exceptions, but in the present day with the products of the study of physical science in close relationship to every phase of modern activities, it is a reasonable assumption borne out by the performances of many young persons. But if the student is now more experienced than his forerunner of yesteryear, his task has become correspondingly more difficult. Those subtleties of recent research, which promise in the course of time to make physical science derivable from one fundamental principle, impose upon the student a far greater effort in achieving a satisfactory knowledge of the subject than was formerly the case, and upon an author in gathering in efficient pedagogical form the various topics of physical science in harmony with modern conceptions.

The author has been mindful of this requirement in developing the subject in such sequence as to emphasize the unifying effect of recent discoveries upon the classical divisions of physics—mechanics, heat, light and electricity. Early in the program he introduces ideas formerly found only in treatises on chemistry—conservation of mass, the law of multiple proportions, Avogadro's law, then gas pressure and the kinetic theory of matter and related topics. In the field of electricity, we find cathode rays, electrons, thermionic emission and radioactivity. These modernistic topics are all introduced in suitable relation to the customary topics of a text book on physics. The Michelson-Morley experiment and relativity are of course included under "light" and further along we have the origin of spectra and the quantum theory. Finally wave mechanics and stellar physics and cosmic rays are discussed.

Regarding the ambitious program of this Introduction, the author says: "the average student finds time for only a single elementary course in this as in most other subjects. The possibility of compressing into this space the necessary fundamental training and at the same time giving the broader outlook over modern physics is not generally conceded, but it must be admitted that, if possible, it should be attempted." Here apparently is a conflict between quality and quantity, and it is a question of considerable importance how much matter of a rather descriptive nature should be provided in a course of physics at the expense of fundamental training with the object of providing the student with a comprehensive view. Meticulous training at times has been a bit overdone by teachers of physics, and there may be much to be said in favor of the broader viewpoint recommended by Dr. Miller—but, in the space of one year? That is asking a great deal.

LUCIEN E. PICOLET.

L'AZÉOTROPISME, LA TENSION DE VAPEUR DES MÉLANGES DE LIQUIDES. Bibliographie. Par Maurice Lecat. ix–136 pages, 15 × 23 cms., cloth. Bruxelles, Maurice Lamertin, Editeur, 1932. Price 15 belgas.

It was in 1860, the author of this bibliography tells us, that certain investigators became convinced that a fixed temperature of distillation at a given

pressure of a liquid mass is not a criterion of the uniqueness of substance. This was the real beginning of progress in the study of the vapor pressures of mixtures of liquids which the author has called "azeotropy," a name now widely accepted in the terminology of physical chemistry. Apparently no formal treatise on the subject has yet been written and the large number of contributions on the subject which have appeared have been published in the proceedings of scientific societies and technical periodicals of many lands. Thus, the labor-saving value of this collection is unusually helpful. The work is conveniently arranged. First is provided an alphabetical list of 1380 references under the names of authors. This covers ninety pages which are printed on one face of the leaf, the other being left blank for additional entries. The second list is chronological, by authors, with references by number to the first list. A third list comprises a collection of university theses arranged according to the locality of their origin with numbers referring to the first or author list.

The discriminating labor which is represented in this excellently arranged compilation will doubtless earn for Dr. Lecat the grateful acknowledgments of investigators who may have occasion to delve deeply into the subject of azeotropism.

L. E. P.

PUBLICATIONS RECEIVED.

Our Mineral Civilization, by Thomas T. Read, 165 pages, 13 × 19 cms. Baltimore, Williams & Wilkins Company, 1932. Price $1.00.

Telephone Theory and Practice, Automatic Switching and Auxiliary Equipment, by Kempster B. Miller, 494 pages, illustrations, 15.5 × 23.5 cms. New York, McGraw-Hill Book Company, Inc., 1933. Price $5.00.

Telephone Theory and Practice, Manual Switching and Substation Equipment, by Kempster B. Miller, 439 pages, illustrations, 15.5 × 23.5 cms. New York, McGraw-Hill Book Company, Inc., 1933. Price $5.00.

La Transformation de l'Energie electrique II. Commutatrices et Redresseurs, par Henri Giroz, 217 pages, diagrams, 11 × 17 cms. Paris, Librarie Armand Colin, 1932. Price 10 fr. 50.

Les Radio-Communications Modernes, par Pierre David, 149 pages, diagrams, 13.5 × 20.5 cms. Paris, Librairie J.-B. Bailliere et Fils, 1932. Price 20 francs.

The Physical Society, Report on Band-Spectra of Diatomic Molecules, by W. Jevons, 308 pages, tables, diagrams, 18 × 26 cms. London, The Physical Society, 1932.

Rundfunk-Jahrbuch 1933, herausgegeben von der Reichs-Rundfunk Gesellschaft, 167 pages, illustrations, 17.7 × 24.5 cms. Berlin, Arbeitsgemeinschaft von Verlegern Offizieller Funkzeitschriften, 1932.

U. S. Bureau of Mines, Cobalt, Molybdenum, Tantalum and Titanium in 1931, by P. M. Tyler and A. V. Petar, 16 pages, tables 15 × 23 cms. Washington, Government Printing Office, 1932, price five cents. Platinum and Allied Metals, by H. W. Davis, 12 pages, tables, 15 × 23 cms. Washington, Government Printing Office, 1932, price five cents. Feldspar in 1931, by H. H. Hughes and Jefferson Middleton, 11 pages, tables, 15 × 23 cms. Washington, Government Printing Office, 1932, price five cents. Technical Paper 541, A Study of Mine

Roof of the Pittsburgh Coal Bed in the Pittsburgh Mining District, by J. W. Paul and L. N. Plein, 98 pages, tables, illustrations, 15 × 23 cms. Washington, Government Printing Office, 1932, price ten cents.

Canada Department of Mines, Investigations of Mineral Resources and the Mining Industry, 1931, 153 pages, tables, plates, illustrations, 16.5 × 24.5 cms. Ottawa, King's Printer, 1932.

Ontario Department of Mines, Forty-first Annual Report, part I, 150 pages, tables, 16.5 × 24.5 cms. Toronto, King's Printer, 1932. Part III, 59 pages, tables, illustrations, 16.5 × 24.5 cms. Toronto, King's Printer, 1932.

Index to A. S. T. M. Standards and Tentative Standards, 119 pages, 15 × 23 cms. Philadelphia, American Society for Testing Materials, 1932.

National Advisory Committee for Aeronautics, Technical Notes: No. 436, The Effect of Connecting-Passage Diameter on the Performance of a Compression-Ignition Engine with a Precombustion Chamber, by C. S. Moore and J. H. Collins, Jr., 14 pages, figures, tables, 20 × 26 cms. Washington, Committee, 1932. No. 437, The Pressure Distribution over a Long Elliptical Wing Tip on a Biplane in Flight, by Richard V. Rhode, 8 pages, figures, tables, 20 × 26 cms. Washington, Committee, 1932. No. 438, The Gaseous Explosive Reaction at Constant Pressure—Further Data on the Effect of Inert Gases, by F. W. Stevens, 16 pages, figures, tables, 20 × 26 cms. Washington, Committee, 1932. No. 439, Meteorological Conditions During the Formation of Ice on Aircraft, by L. T. Samuels, 20 pages, figures, tables, 20 × 26 cms. Washington, Committee, 1932. No. 440, Flight Tests to Determine the Effect of a Fixed Auxiliary Airfoil on the Lift and Drag of a Parasol Monoplane, by Hartley A. Soule, 9 pages, figures, 20 × 26 cms. Washington, Committee, 1932. No. 441, Rolling, Yawing and Hinge Moments Produced by Rectangular Ailerons, by R. H. Heald, 12 pages, tables, figures, 20 × 26 cms. Washington, Committee, 1933.

Bell Telephone Laboratories, Monographs: B-696, A Portable 16 MM. Sound Picture System, by R. A. Miller and H. Pfannenstiehl, 11 pages, illustrations, 15 × 23 cms. B-697, Frequency Distribution of Atmospheric Noise, by R. K. Potter, 7 pages, diagrams, 15 × 23 cms. B-698, Current Propagation in Electric Railway Systems, by John Riordan, 24 pages, diagrams, 15 × 23 cms. B-702, The Conception and Demonstration of Electron Waves, by C. J. Davisson, 17 pages, diagrams, 15 × 23 cms. B-704, Expansion for Laplacian Integrals in Terms of Incomplete Gamma Functions, by Edward G. Molina, 13 pages, tables, 15 × 23 cms. New York, 1933.

CURRENT TOPICS.

Radon Seeds.—Radium, a well-known radioactive element of great therapeutic value, gradually disintegrates into a gas called Radon. Radon gas, like its parent, emits radiations which may be looked upon as X-rays of relatively short wave-length. Such radiations are used in the treatment of some forms of cancer.

From G. H. LASH, Press Representative of the Canadian National Railway, we learn that the University of Toronto is installing a plant to handle these radium emanations or Radon. The substance is to be put up in tiny gold tubes and the preparations are known as Radon seeds.

C.

Combination Luminaries.—Improvements in illumination continue. One of the goals of the illuminating engineer is the duplication of sunlight in artificial lighting. The well-known incandescent lamp has an excess of red and yellow rays and a deficiency of blue rays. The usual method has been to simply filter out the excess rays by means of a blue or bluish-green glass in an attempt to obtain artificial daylight. This might be termed the "subtractive process" and naturally is very inefficient. In the new combination luminaries the blue-ray deficiency of the incandescent lamp is compensated by the blue-green spectrum of the mercury vapor lamp. This "additive process" is much more efficient and can be controlled so as to give a very close approximation to natural daylight.

This recently developed combination of incandescent and mercury vapor lamps is practically shadowless and remarkably free from both direct and reflected glare. For the same lumen output the mercury tube generates much less heat than the radiant film of an incandescent lamp. Thus a much higher "foot candle" intensity is possible with less discomfort from radiant heat. Furthermore, the bluish green light is psychologically much cooler than the yellow-red light. The "seeable" quality is due to the fact that the maximum light output of the mercury vapor lamp is in the zone of maximum visual acuity of the human eye.

The luminous efficiency of a 1000-watt incandescent lamp is 20.6 lumens per watt. (A foot-candle is equivalent to one lumen per square foot.) A fifty-inch mercury tube has an efficiency of 15.2 lumens per watt. The various combinations now available

range from 18.9 to 16.2 lumens per watt efficiency. Since the mercury tubes are made of glass, the ultra-violet rays are absorbed and only the visible portion of the mercury vapor spectrum is utilized.

C.

Algebra and Magical Numbers.—A newspaper recently published the following bit of puzzling calculation: Put down the number of your living brothers. Multiply it by two and add three. Multiply the result by five. Add the number of living sisters. Multiply the result by ten. Add the number of dead brothers and sisters. Subtract 150 from the result. A number of three figures is left; the one on the right will be the number of dead brothers and sisters, the middle figure the number of living sisters and the left-hand figure the number of living brothers.

If such formulæ are examined algebraically it seldom is difficult to see why they work out as they do. Let x represent the number of brothers, y the sisters and z the dead brothers and sisters. Proceeding by the steps outlined above one gets, x, $2x + 3$, $5(2x + 3)$, $5(2x + 3) + y$, $10[5(2x + 3) + y]$, $10[5(2x + 3) + y] + z$, $10[5(2x + 3) + y] + z - 150$. Now, clear the brackets and have $100x + 150 + 10y + z - 150$ or $100x + 10y + z$. All is explained. The formula, despite its seeming complicated structure, merely served to place the living brothers in the hundreds column, the sisters in the column of tens and the dead brothers and sisters in the units. Such algebraic analysis may be applied to similar well-known age and birth-date problems.

C.

The Sodium Lamp.—Speaking on the probable applications of gaseous-tube lighting, WARD HARRISON in the *Electrical World* (Nov. 19, 1932) states that of the various tube sources now in the course of development, the one employing sodium vapor as the light source appears to be the most promising from the efficiency standpoint. The efficiency of an individual lamp depends to a considerable extent upon its wattage. Efficiencies of 50 to 70 lumens per watt are indicated for sizes of 300 to 500 watts. The original 130-watt lamp developed by Dr. Pirani had an over-all efficiency as high as 35 lumens per watt. It is debatable whether the efficiency of sodium lamps will offset their inherent high cost except in sizes of 100 watts or more.

A sodium lamp must be constructed of glass which will resist the attack of the very active sodium vapor which it is intended to confine. In addition the tube of sodium vapor must be inclosed

within a second bulb or tube and the space between the two evacuated, at least in the smaller sizes, to prevent the escape of heat. Without this heat insulation the sodium vapor will condense and the operation of the lamp be unsatisfactory.

Psychologically the sodium vapor gives a warm yellow light that is pleasant. This light is monochromatic (one color) rendering color discrimination impossible and is actually less flattering to the human countenance than mercury-vapor light. For street lighting these disadvantages are of lesser moment and it is claimed that the monochromatic character of the light greatly assists vision at the low intensities incident to the out-of-doors. Such a convenient source of monochromatic light should make the sodium lamp especially desirable for testing purposes in chemical laboratories.

C.

Aviation Advances in 1932.—The Eighteenth Annual Report of the National Advisory Committee for Aeronautics is now available. This committee is the governmental agency for coördinating and conducting fundamental research in aeronautics and its recent report describes a number of noteworthy accomplishments for the year just past.

Speed has come in for its share of attention. During the past year the speed of military bombers was increased to a rate greater than that of pursuit-type airplanes of two years ago, and the normal cruising speed of large commercial air transports was increased 20–40 per cent. This notable advance was made possible primarily by improvements in aerodynamic efficiency including especially investigations of the cowling of engines and the determination of the best positions of engines with reference to the wings of multi-engine airplanes.

The Committee has designed a new type of instrument known as the V-G recorder for determining accurately maximum loads on structural members of airplanes. The instrument is attached to the airplane and while in full flight automatically registers on one chart the speed of the machine and the accelerations (the loads imposed upon the structure) due to air flow. It is now possible to calculate accurately the maximum loads imposed on the structural members of any type of airplane, and thus to break away from arbitrary design rules.

An interesting result of wind-tunnel investigations has been the development of a combination of wing and fixed auxiliary airfoil which gives a greater speed range than the main wing alone, a higher maximum lift coefficient, improved pitching moments, and

a much larger range of gliding angles. The auxiliary airfoil has a chord about one-seventh that of the main wing and is located ahead of and approximately parallel to the main wing. As the angle of attack of the combination is raised, the auxiliary airfoil stalls well before the main wing and the turbulent wake from the auxiliary has a scouring action on the air passing over the upper surface of the main wing, which retards the formation of the boundary layer with the result that a higher angle of attack and therefore a higher lift coefficient is reached before the main wing stalls.

Several high-lift devices with movable parts also were investigated during the past year. The Fowler variable-area and variable-camber wing, gave the highest lift having a maximum coefficient of 3.17 as compared with 1.27 for the plain basic wing.

Research conducted with the object of increasing the power output of aircraft engines by increasing the weight of charge taken into the engine cylinder has shown that the removal of the exhaust gases from the clearance volume of a 4-stroke cycle engine results in a gain in power output proportional to the weight of exhaust gases removed. The clearance volume can be efficiently scavenged by overlapping the timing of the inlet and exhaust valves and maintaining a slight boost pressure in the inlet manifold. The loss of fuel with the scavenging air can be avoided by replacing the carburetor with a fuel-injection system and timing the injection of fuel into the engine cylinder. Tests on a single-cylinder engine showed a power increase of 18 per cent. of that obtained with normal valve timing and a carburetor.

The investigation of safety fuels for aircraft has continued. If a fuel having a flash point of 105° F. under atmospheric conditions can be used the fire hazard will have been reduced appreciably. A fuel of this type would operate by being injected into the cylinder in the form of a fine spray. Unlike the Diesel, these engines would still use spark ignition.

In respect to transoceanic air transport the Committee feels that in a service to Europe greater cruising range and carrying capacity are required than can be efficiently provided in heavier-than-air craft at the present stage of aeronautical development. Rigid airships at this time offer a prospect for air passenger service to Europe.

C.

The Pliotron.—In a paper, "New Vacuum Valves and Their Applications," DR. A. W. HULL, Assistant Director of the Research Laboratory, General Electric Co., describes the smallest member of the vacuum tube family. Designated as Pliotron FP-54, this tube

is smallest in respect to performance rather than size. Its function is to measure currents smaller than any yet detected. The secret of this tube's ultra-performance lies in a mode of construction that eliminates as far as possible all foreign and stray currents generally considered as a characteristic of the tube. An extra "space-charge" grid, maintained at 3 volts positive with respect to the filament, holds back the small but pernicious current of positive ions omitted by the filament. Other conditions are regulated so there will be an elimination of grid-currents, which may consist not only of insulation leakage and positive ions from the hot filament and from residual gases, but of high speed electrons from the filament, photo-emission from the grid due to the light of the filament, and electron emission caused by X-rays generated by the impact of electrons on the plate.

The present sensitivity of this new tube is slightly better than that of the most sensitive electrometer, over which it has an enormous advantage in sturdiness. The smallest current that can be measured is 1×10^{-18} amperes, one billion-billionth of our common electrical unit. Such micro-current is equivalent to a flow of approximately six electrons per second, truly a more satisfactory way of looking at it. This micro-tube makes an excellent research tool. It will count cosmic rays. It is capable, with the coöperation of a photoelectric cell, of detecting the light from a star of the 14th magnitude. It will record the fragments—neutrons, protons and alpha particles—of atomic nuclei smashed by high-speed ions.

Another form of Pliotron has been constructed for measuring voltages ten times smaller than could be detected before. The virtue of this tube lies in its especially good vacuum. In tubes of relatively poor vacuum an appreciable portion of the electron current is shared by the positive ions. In the best vacuum now obtainable this positive ion current is virtually absent since the residual gases have been removed with a high degree of thoroughness. In such tubes a faint, erratic current can be detected by means of a milliammeter. Smoothness of this current flow is impossible since it consists of finite grains (electrons). This so-called "shot effect," the irregularity of the patter of electrons on the plate, can be calculated and measured, electrically. It is equivalent, in an ordinary amplifying tube, to an input signal of about 1 microvolt. Now with the improved vacuum in this new Pliotron, the low-frequency input noise level of less than ½ microvolt represents the present low limit of voltage detection. Such a tube may prove valuable in physiological studies such as the measuring of heart-beats, nerve impulses and even thought waves.

Power Pliotrons also are available. These tubes, the derivation of their name meaning very high vacuum, may be had in sizes ranging from 5 watts to 500 kilowatts. Industrial applications may include the high-frequency heating of metals; high-frequency heating of people—at present for producing benign fevers that have been found effective in the treatment of paresis and arthritis; the sterilization of milk, grain, fruit, bulbs; the production of ozone.

C.

The Thyratron.—According to DR. A. W. HULL the Thyratron tube is a grid-controlled arc discharge device. In structural form it is similar to the Pliotron but in other respects it differs almost as much as day and night. The electron current in the Pliotron must be very pure; the presence of a few positive ions spoils the space-charge, limiting repulsions on which its whole action depends. The electron current in the Thyratron, on the other hand, must be 100 per cent. impure, i.e., it must have as many positive ions as electrons. Electron repulsions are so completely neutralized by the presence of the positive ions that 10,000 times as many electrons can be crowded into the space. Hence the thyratron can carry larger currents with lower voltage drop—amperes instead of milliamperes, with a few volts, from 10 to 18, between anode and cathode, instead of hundreds of volts.

A second fundamental difference between the tubes is that the grid of the thyratron only partially controls the current flow. It can control only the starting of the current and once started is practically powerless to control its flow or to stop it. Inability to stop the current is not a serious one, since it will stop whenever the anode voltage reverses.

The reason a negative grid ordinarily cannot stop or control the discharge is that it attracts to its neighborhood enough positive ions to neutralize exactly its own negative charge. Hence, in order to regain control, the discharge must be stopped only long enough to allow the ions to diffuse to the walls. This time varies, according to grid mesh and vapor pressure, from about 50 to 200 microseconds. In many types of thyratron tubes the gas needed to supply the positive ions is mercury vapor arising from a drop of this element located in a cool place at the bottom of the tube. The largest thyratron available has a cathode consisting of a pool of mercury. The twelve anodes and grids are placed in side arms. The whole set-up has a continuous current rating of 5000 amperes d.c. at voltages up to 1500.

The largest field of application for thyratrons, at the present time, is as power amplifiers for controlling mechanical operations.

By varying the phase of the grid voltage in respect to the anode or plate voltage a smooth variation of average current, from maximum value to zero, may be obtained through the tube. This phase-control method may be used for the dimming of theatre lights. In this case, the Thyratron current controls the lamps by saturating reactors in series with the lamps, thus varying the impedance in the lamp circuits, and hence the current through the lamps.

For spot-welding the magnitude of the grid voltage is varied rather than the phase. A synchronous timing device applies voltage to the grid for certain definite intervals, the current passing while this voltage is on and ceasing when it is off. The passing of the current acts as a short-circuit on one winding of a series transformer, thus varying the impedance of the other winding, which is in series with the primary of the welding transformer. In the welding operation the Thyratron simply plays the part of a contactor, but is the kind that does not wear out, is inertialess, accurate, and controlled by minute power.

Thyratrons cannot generate electric power, but they are ideally adapted to the task of converting it from one form to another which they accomplish without motion, noise or wear. They may be used for: changing direct current to alternating (inverter operation), alternating to direct (rectifier), direct current from one voltage to another (d.c. transformer), alternating current from one frequency to another (frequency changer), correcting power factor (static synchronous converter), or even replacing commutators on motors.

C.

The Phanotron.—DR. A. W. HULL describes the Phanotron as a gas-filled, arc-discharge rectifier whose electron emission is furnished by a hot cathode. This tube is an improvement over the older and better known Tungar rectifier. This latter has a large tungsten filament for a cathode and is made to emit large quantities of electrons by heating it to an excessive temperature. The tube is filled with argon gas at 5 cm. pressure (mercury) in order to prevent evaporation of the tungsten filament at this high temperature. This high pressure imposes two limitations: the voltage that can be rectified is low, because the sparking potential of argon at these pressures is only 200 volts; and the current is limited by the concentration of the arc, which tends to overheat the filament.

In the Phanotron, the gas pressure is much lower, between .005 mm. and 0.05 mm. At this low pressure, the cathode must be operated at " normal " temperatures so as to prevent its rapid disintegration. The problem of securing a sufficient electron emission is solved by making the cathode of ample size and so constructing

it that its heat loss is small taking advantage of the fact that electrons in an arc-discharge can go around corners, while heat-radiation must go in straight lines. This combination of heat-shielded cathode and low-pressure gas appears to give the four desired characteristics of a rectifier: high voltage, large current capacity, high efficiency and long life.

Phanotrons may be constructed according to the performance demanded. One type is rated to withstand 20,000 volts peak inverse voltage and to deliver a maximum current of 40 amperes. Another tube requires 400 watts to maintain the cathode temperature, is rated at 600 amperes maximum output, 100 amperes average, at any inverse voltage up to 1500.

C.

Anti-Phymin.—(U. S. Department of Agriculture Clip Sheet No. 756.) The manufacturer of this preparation labelled it as a cure for many serious diseases, including tuberculosis and diabetes. The maker also claimed his concoction would cure disease through controlling bacterial fermentation. Analysis proved the product to consist merely of a weak solution of sulfur dioxide and water. It had no bactericidal value.

C.

What Is Being Done With Nickel.—ROBERT C. STANLEY, President of the International Nickel Company of Canada, Ltd., is the author of a paper recounting the part played by nickel in industry during the past year. Naturally, these past accomplishments foreshadow much of what is to be and so lend heightened interest to a report of this type.

Pure nickel serves a wide variety of industries as evidenced by the relatively large tonnages going into such entirely diversified fields as alkali, rayon, plastic and radio tube manufacture. Pure nickel tubing has proved very suitable for caustic evaporators, especially where a copper-free caustic is required for rayon manufacture. Nickel-clad steel plate is now available and is a promising material of construction for tank cars transporting concentrated alkali liquors. Structurally, a non-porous layer of pure rolled nickel is permanently and inseparably bonded to a heavier layer of steel to give a combination having high corrosion resistance and structural strength at relatively low cost. It is now being used in soap kettles, hot water storage heaters, tank cars for shipping carbolic acid and sugar syrups, large hoppers for handling chemicals, and nitriding boxes for steel parts.

Light, porous nickel objects are being made by compressing the powdered metal into the desired shape and heat-treating. An excellent nickel catalytic mass may be formed by sintering together equal parts of finely divided nickel and aluminum and subsequently dissolving out the latter. In France a new type of storage battery —a nickel-cadmium alkaline cell— has been developed for industrial trucking and train lighting. Nickel coinage is growing in favor and up to the present time some 24 countries have issued about 3,000,000,000 pure nickel coins.

Non-Ferrous Nickel Alloys.

Monel Metal (Approximately 67 per cent. nickel). The past two years have witnessed the development of monel kitchen sinks and cabinet tops. In the cellar, may be found a hot water storage tank of welded monel. Among other uses may be mentioned: Extension in the handling and canning of sea food such as shrimp and oysters, and for lining fish holds and chutes on boats; perforated monel metal spindles for package dyeing of yarn and thread; for identification tags in laundries; development of monel metal sausage and bologna molds, and comb type bacon hangars. Seamless tubing of monel metal makes suitable pipe lines in food, bottling and canning plants.

Inco Chrome Nickel (80 per cent. Nickel). This year-old alloy containing 12 to 14 per cent. chromium is particularly suitable for dairy equipment. Known as Inconel, this alloy is completely stainless and acid resistant. It can be welded without impairment of its stainless qualities and is easily fabricated. It is resistant to brine solutions and non-tarnishing in contact with milk at any temperature.

Solid Nickel Silver (5 per cent. to 30 per cent. Nickel) has been made readily available in cast, rolled or extruded forms. Cast nickel silver goes into the highest grade plumbing fixtures, marine, building and automotive hardware, decorative trim, milk and food handling equipment and in cast fittings for ice cream freezers. Extruded sections are available in more than 2,000 different shapes for the forming of architectural hardware, ornamental grills and the like.

Cupro Nickel Alloys containing 15 per cent. to 50 per cent. nickel make excellent long-life condenser tubes and large numbers have been installed in marine and land steam turbine power plants. Nickel, added to brass, increases its density and tensile strength. A nickel bronze, golden yellow in color, is now available for jobs where the strength and corrosion resistance of brass is not sufficiently high.

Ferrous Nickel Alloys. Nickel Alloy Steel (½ per cent. to 5 per cent. Nickel). Nickel steels are especially adaptable to the nitride hardening process. By this process marginal layers are obtained in alloy steels which have the highest hardness procurable by any of the known methods of heat treatment. Progress in the successful welding of nickel steels has been made and has resulted in the construction of a welded nickel steel gun carriage. The toughness of nickel alloy steels renders them particularly suitable in machinery for excavating, construction and road maintenance; petroleum drilling equipment and coal-cutting machinery.

An outstanding application of stainless steel has been its use in the construction of digesters for making sulfite pulp. Nickel Cast Iron is noted for its great wearing qualities and is particularly suitable for cylinders or cylinder sleeves and pistons, especially as applied to Diesel engines.

Ni-Hard, a hard-wearing cast iron containing 4½ per cent. nickel, is used in both finishing rolls and in hot mill service rolls. Its wearing qualities have made it useful for centerless grinder supports, pump plungers, pulverizing equipment, cement mills, crusher dies, coffee mill burrs, sand pumps and pneumatic scale knife edges.

Ni-Resist is a cast iron containing approximately 14 per cent. nickel, 6 per cent. copper and 2 per cent. chromium. It is very corrosion- and heat-resistant and has done excellent service in engine pumps and manifolds, valve seats, heat control valves, valves for corrosive liquids, cyanide pots, filter parts and electrical resistance grids.

A Nickel Wrought Iron has been developed and shows characteristics superior to those of the ordinary variety. Invar and Elinvar are two ferro alloys containing from 32 per cent. to 45 per cent. nickel. Invar's prime value lies in the fact that its length varies only minutely with temperature changes while Elinvar boasts an invariable elasticity. This latter alloy is especially suitable for watch springs and those of spring balances. During the past year two non-magnetic steel castings containing 22 per cent. nickel and weighing over 22 tons each were constructed to serve as important parts of electrical machinery.

C.

Plating with Metal Mists.—(*Brass World*, Oct. 1932.) A method for depositing extremely thin films of metal has been developed by DR. JOHN STRONG of the Norman Bridge Laboratory of Physics of the California Institute of Technology after spending two years of research and experiment. The process is carried out

in a vacuum chamber at high temperatures and is applicable not only to metals but to any relatively dry materials such as paper, dry wood, cloth, bone, stone, glass and leather.

The method of operation consists in placing a sliver of the plating metal inside a small tungsten wire coil suspended between two metal posts or standards. An electric current heats the coil and the metal within. At high temperatures (about 2000° C. for platinum) a fine metallic mist begins to rise from the metal sliver and covers everything within the vacuum chamber with a coating of unusual uniformity. Successful mist plating has been done not only with platinum, but with gold, silver, tin, aluminum, iridium and copper. Probably any metal can be used whose "mist heat" is less than that of tungsten.

"Mist plating" has been particularly successful in the metallizing of mirrors. Glass can be plated with a film of gold approximately one 100,000th of an inch in thickness. Such a film is visible only when the plate is held horizontally at eye level so that the observer may view the apparent compounding of the plating effect. Held vertically, the film becomes transparent although a slight fogginess can be observed. It would not be impossible to utilise such a plating process on a commercial scale. A relatively large metal chamber with observation ports would replace the bell jar of the laboratory. The plating of paper, wood or cloth should present little difficulty when done by this method.

C.

Faking the Chemist.—(*Food Industries*, Aug. 1932.) It is customary for manufacturers to advertise now and then the fact that their products are made under the close supervision of a control chemist and run, along with the advertisement, the picture of a white-coated individual peering through a microscope, holding a test tube up to the light or occupied with one of many well known chemical manipulations.

If such genuine chemical control is exercised in the manufacture of a product, the producer displays a justifiable pride in telling prospective purchasers about it.

However, not all advertising is strictly ethical and there is the case of a manufacturer who will, through the advertising medium of his chemist, create impressions which misrepresent the true conditions existing in the manufacture of his products.

A little over a year ago a food manufacturer showed a chemist seated at a desk looking intently into a microscope. In front of him on the desk were bottles and cans representing the products of the manufacturer. The accompanying descriptive matter was so

worded as to give the reader the impression that every product was produced under the closest supervision of a food chemist. The only admirable part of the advertisement was the courage and daring of the manufacturer in having it published. The "chemist" was none other than the production manager and the microscope had been borrowed from a local hospital.

C.

Chemistry Notes from Hungary.—(News Edition, *Ind. & Eng. Chem.*, Oct. 10, 1932.) S. S. DE FINÁLY, writer of the letter, announces that the cosmetic chemists are trying out a new complexion powder named "Sulfamyl." This powder contains finely dispersed colloidal sulfur which is said to be a good skin disinfectant and drier. There is also a face cream to which vitamins have been added. They are supposed to have an accelerating influence on the activity of the skin cells and aid in the smoothing of face wrinkles.

To most people, the odor of cresol derivatives is decidedly unpleasant. A Hungary firm has secured a patent on a method for eliminating the bad smell. The cresol is dissolved in alcohol and the solution gelatinised by the addition of sodium stearate (tallow soap).

A Hungary poultry farm has been investigating the feeding of iodine-containing food to hens. They find the iodine content of eggs can be increased only to a certain limit—about 2.5 milligrams or one twenty-seventh of a grain.

C.

Exploding Wood Fibers.—Not so many years ago the attention of the country's eaters was drawn to certain puffed cereals—the food shot from guns. Today, wood chips are undergoing a similar treatment, although it is not popularly advertised and the public are not asked to eat it.

Henry K. Benson, in the Twenty-second Report of the National Committee on Wood Utilization, describes a process for exploding wood developed by W. H. MASON. The process has the advantage of being able to use waste material such as sawmill edgings, slabs, shavings, bark, splinters or sawdust. The wood is chipped and screened to a size three-eighths to 1 inch in length. These chips are fed into an explosion chamber 20 inches in diameter and 5 feet high, having a capacity of 10 cubic feet. There is a charging manhole at the top and a quick-acting hydraulic release valve at the bottom. After filling, the explosion chamber or "gun" is tightly

closed and steam at 350 pounds pressure introduced. The temperature rises to about 375° F., which is maintained for 30 to 40 seconds, after which high pressure steam at 1,000 pounds per square inch is added and held for 5 seconds, the temperature reaching 540° F.

The hydraulic discharge valve is now opened and the escaping chips explode immediately, due to the high internal pressure. The chips are thus transformed into masses of long fiber bundles and individual fibers. The steam is separated in a "cyclone" and the fibers are dropped into water at 160° F. After screening, petrolatum or paraffin is added and the fibers go to a machine where they are felted into a board. The nature of the board is chiefly determined by the treatment it receives in the drying press. A highly polished chrome-surfaced platen and a pressure of 200 to 400 pounds per square inch produces a very hard and dense board. Lower pressures and ordinary platens are used in making a more porous type. The board may have a specific gravity ranging from 0.30 to 1.05.

C.

Sulfite Waste Liquor—What It Is Good For. Of the various methods for manufacturing chemical pulp, the sulfite process rates highest in importance. Sulfite pulp is used in the production of print paper, wrapping paper, writing paper, tissues, paper toweling, wax paper, grease-proof paper, imitation parchment and is a constituent in newsprint, book paper and wall paper.

Preparation of sulfite pulp consists in cooking wood chips in a liquor of free sulfurous acid and calcium bisulfite. The time, pressure and temperature vary somewhat depending upon the type of wood. The action of the sulfurous acid and of the bisulfite results in the hydrolysis of the hemicelluloses of wood into soluble sugars and in the formation of reaction products with the lignin, which are soluble in water. For every ton of pulp manufactured approximately 2,000 gallons of sulfite waste liquor containing around 10 per cent. of dissolved solids are produced. That is, for every ton of pulp, there is for disposal an equal weight of dissolved wood substance in the waste liquors. Thus, in one year in the United States and Canada over 2,000,000 tons of solids create not only the problem of utilizing this huge bulk of waste material, but the more immediate task of effecting its disposal in a manner that shall not be objectionable to the surrounding community.

By suitable treatment, sulfite waste liquor may be prepared for use as a binder. Methods of preparation vary in detail, but it is customary to neutralize the acidity with lime, then evaporate the

liquor to 50 per cent. solids or even to a dry powder. In both these forms its use in Sweden for dust-laying and road improvement has rapidly increased in recent years. The lower half of Sweden has been made practically dustless through the use of sulfite liquor on the roads. In the United States, sulfite liquor has been used for road-building purposes under the name of lignin binder. To be successful on gravel, it should contain at least 10 to 12 per cent. of clay binder or other active silicious matter.

The durability of linoleum is proportional to the quality of the cement used in fastening it to the surfaces it covers. A very satisfactory cement can be had by incorporating a clay base and a preservative against fermentation in a concentrated sulfite liquor.

Sulfite liquor shows great promise as a binder in coal briquets. A mixture of 3 per cent. sulfur, 8 per cent. asphalt and 89 per cent. non-caking coal makes a briquet that holds its shape while burning in an open grate. Sulfite-liquor concentrates, due to their content of sulfur and organic matter, show a somewhat similar effect.

Sulfite Cellulose Extract, a tanning product, may be made from sulfite waste liquor. In its production, the free acidity is first neutralized with dolomitic lime. To remove the excess lime a calculated amount of sulfuric acid is added and the precipitated calcium sulfate removed by settling or filtration. The residual liquor is then concentrated by evaporation to give a solid content of 50 per cent. or more. This sulfite cellulose extract contains a relatively high percentage of nontannins and is generally used in connection with regular vegetable tannin extracts giving a leather of good color and quality.

Sulfite waste liquors contain sugars arising from the hydrolysis of the hemicelluloses and to a limited extent from cellulose itself. The manufacture of alcohol from these sugars has been attempted in the United States, but without commercial success. Briefly the procedure consists of first neutralizing the sulfurous acid with calcium carbonate throwing it down as sulfite of lime. After aëration and settling the clear liquor is decanted or filtered and pumped to the fermentation tanks where it is charged with yeast. Fermentation proceeds for about 72 hours after which it is distilled and rectified in the usual manner. A yield of slightly more than 15 gallons of 95 per cent. alcohol per ton of sulfite pulp has been reported.

Sulfite waste liquor is a source of fuel. A mill producing 150 tons of sulfite pulp per day will discharge from the digestors over 300,000 gallons of liquor daily, containing from 125 to 150 tons of combustible matter, 26 tons lime and 22 tons of sulfur. The daily fuel content of the liquor from a 150 ton mill would be equivalent

to 100 tons of coal of 14,500 B.t.u. In preparing the fuel, the moisture may be removed by evaporation or spray drying.

It has been shown that a lime-sulfur spray can be produced from sulfite waste liquor by saturating with hydrogen sulfide gas which transforms the calcium bisulfite into calcium sulfide and finely divided sulfur. The organic matter seems to keep the sulfur in a state of fine suspension and aids in its spreading power.

A number of additional miscellaneous uses are indicated by the reports of various researchers. By treatment with nitric acid, sulfite waste has yielded a yellow dyestuff. In Finland and Norway newspaper printing ink is now produced from sulfite waste liquor. A green laundry soap is also made from this source. Considerable attention has been given to the manufacture of yeast from sulfite waste liquor. It is possible to reclaim 300 pounds of yeast per ton of pulp produced by the mill.

Undoubtedly the utilization of sulfite waste liquor will provide chemists and engineers with absorbing problems for many years to come. Progress to date has not outgrown the preliminary stage. The more immediate problems are those having to do with methods for concentrating economically the solid content of the liquors. The development of corrosion-resistant alloys and waste-heat utilization will aid greatly in this problem.

C.

Vitamin D Milk.—When irradiated yeast is included in the ration of the cow, the milk is high in antirachitic properties, and is an excellent source of vitamin D. EDWIN T. WYMAN AND ALLAN M. BUTLER (*Am. Jour. Diseases of Children*, 1932, xliii, 1509–1518) have used such milk in the diet of rachitic infants and children, and checked the results by roentgenograms and by determination of the calcium-phosphorus product of the blood. Healing occurred in advanced active rickets in infants, and in advanced chronic rickets in children. The milk still possessed antirachitic properties after it had been boiled for 5 minutes.

J. S. H.

Cobalt in Animal Nutrition.—F. J. STARE AND C. A. ELVEHJEM (*Jour. Biol. Chem.*, 1933, xcix, 473–483) have found less than 0.01 milligram of cobalt in the entire body of rats fed a basal ration containing milk, and salts of iron, copper, and manganese. When cobalt salt, representing from 0.1 to 2.0 milligrams of cobalt in the daily ration of each rat, was added to the basal ration, cobalt was found in the body of every rat, and the amount present was proportional to the amount fed. A cobalt content of 0.04 to 0.05 milli-

gram in the entire body sufficed to produce in the rat a definite polycythemia or excess of red corpuscles in the blood. Cobalt was not found in the tissues of pigs fed the basal ration, but definite quantities of cobalt were present in the tissues of pigs fed a similar ration plus cobalt salt.

J. S. H.

Decomposition of Mineral Oils by Sunlight.—L. W. GREEN AND R. E. SCHOETZOW (*Jour. Am. Pharm. Asso.*, 1932, xxi, 1286–1287) report that mineral oil (heavy liquid petrolatum, U. S. P.), bottled in flint glass, and exposed to the sunlight, may develop a disagreeable odor and taste. The rate of spoilage depends on the geographical source of the crude oil. The stability of such oil may be ascertained by bottling in flint glass, and then exposing to ultraviolet light for comparatively short periods of time (3 to 49 hours).

J. S. H.

Color Test for Rotenone.—HOWARD A. JONES AND CHARLES M. SMITH (*Ind. & Eng. Chem.*, Analytical Edition, 1933, v, 75–76) described the following color reaction of the insecticide rotenone. The test will reveal the presence of as little as 0.1 milligram of rotenone. Mix 1 cc. of the acetone solution of rotenone with 1 cc. of dilute (1 to 1) nitric acid, and let stand 30 seconds. Then dilute with 8 or 9 cc. of water, and add 1 cc. of concentrated ammonia water. A blue color is obtained, almost identical with that yielded by bromothymol blue at pH 7.2. The insecticide deguelin, which, like rotenone, is of vegetable origin, also gives this reaction.

J. S. H.

New Reagent for Zinc.—ARMAND J. QUICK (*Ind. & Eng. Chem.*, Analytical Edition, 1933, v, 26) recommends borneolglycuronic acid as a reagent for zinc. A 5 per cent. aqueous solution of this acid forms a characteristic crystalline precipitate, $(C_{16}H_{25}O_7)_2Zn.2H_2O$, when added to a solution containing as little as 0.03 per cent. of zinc in solution. The crystals are white and glistening. The precipitate may be weighed; or it may be hydrolyzed by boiling with normal hydrochloric acid for 15 minutes, and the liberated glycuronic acid then be determined by any of the common sugar methods. Of the common metals, only cadmium behaves in a similar manner.

J. S. H.

Sodium-Lead Alloy.—CHARLES W. STILLWELL AND WALTER K. ROBINSON (*Jour. Am. Chem. Soc.*, 1933, lv, 127–129) have applied

the diffraction method for the analysis of the alloy usually designated Na_4Pb_1 and find that the more exact formula is $Na_{31}Pb_8$.

J. S. H.

Density of Ammonia.—GERHARD DIETRICHSON, LOUIS J. BIRCHER, AND JOHN J. O'BRIEN (*Jour. Am. Chem. Soc.*, 1933, lv, 1–13) have determined the density of synthetic, anhydrous, gaseous ammonia. The normal density, expressed in grams per liter at atmospheric pressure and 0° C., is 0.77126 ± 0.00001.

J. S. H.

Test for Pectin.—IRWIN STONE AND RAYMOND ROHNER (*Chemist Analyst*, 1932, xxi, No. 6, 10) describe the following test for pectin. The gum, or the alcohol precipitate obtained from its solution, is dissolved in 50 cc. of boiling water. The resulting solution is cooled to approximately 70° C., mixed with 5 cc. of 20 per cent. sodium hydroxide solution, and then let stand for approximately 10 minutes. The alkali saponifies the methyl ester in the pectin, in which the methyl radical apparently is attached to the carboxyl residue of the galacturonic acid group. The solution is next made acid to litmus by addition of dilute sulphuric acid, then distilled. Five cc. of distillate are collected, and tested for the presence of methanol by a modified pharmacopœial test for that alcohol. With 25 milligrams of pectin, the characteristic color appears within 10 minutes after all the reagents have been added, while a positive reaction is obtained within 30 minutes with 10 milligrams of pectin. Gum tragacanth gives a markedly positive reaction, the following substances a negative reaction: agar agar, Irish moss, dextrin, potato starch, corn starch, quince seed mucilage, locust bean flour, galagum, gum Arabic, and karaya gum.

J. S. H.

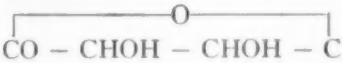
Impurities in Mercury.—AARON ISAACS (*Jour. Am. Dental Asso.*, 1932, xix, 54–57) states that the presence of 0.001 per cent. of a base metal (lead, bismuth, copper, cadmium, antimony, tin, zinc) in mercury changes the appearance of the latter. A film forms on the surface, or the glass container may be wet and cannot be emptied completely of its contents. If arsenic be soluble in mercury, its maximum concentration is a mere fraction of 0.001 per cent. The presence of as much as 0.1 per cent. of gold or silver does not change the appearance of mercury.

J. S. H.

Two New Elements.—In a paper on the magneto-optic method of analysis, FRED ALLISON (*Jour. Chem. Ed.*, 1933, x, 71–78) describes the detection of two new chemical elements by this method. Alabamine, eka-iodine, element no. 85, occurs in sea water, fluorite, apatite, monazite sand, pitchblende, and, in fact, is fairly widespread, but is present only in extremely minute amounts; the greatest observed concentration is 1 part in a billion. Virginium, eka-cesium, element no. 87, occurs in sea water, Searles Lake brine, crude cesium salts, pollucite, lepidolite, monazite sand, samarskite, and pitchblende.

J. S. H.

Vitamin C.—W. N. HAWORTH, E. L. HIRST, AND R. J. W. REYNOLDS (*Nature*, 1932, cxxix, 576–577) have examined the hexuronic acid which, according to Svirbely and Szent-Györgyi, is water-soluble C, the vitamin which prevents scurvy. They find that it most probably is the 6-carboxylic acid of a ketohexose which apparently is not related to either *d*-fructose or the ketose corresponding to *d*-galactose. They assign to it a lactone formula,



J. S. H.

Paracelsus Library.—A recent brochure of The Hahnemann Medical College of Philadelphia, dated 1932, contains a twelve page description (pages 7 to 18) of the collection of the works of Paracelsus (1490–1541) which belonged to the late Dr. Constantine Hering and is now the property of the College. The works of Paracelsus are of deep interest to the student of the history of chemistry. Dr. Hering collected 189 volumes of the original works, commentaries and translations.

His collection also includes a number of pamphlets by or about Paracelsus. It is especially rich in editions of the 16th and 17th centuries. A copy of the brochure has been deposited in the library of the Franklin Institute.

J. S. H.

Death of Monroe B. Snyder.—On September 27, 1932, Monroe Benjamin Snyder, emeritus professor of astronomy and mathematics in the Central High School of Philadelphia and a member of the Franklin Institute, died at Narberth, Pa. Professor Snyder was born at Quakertown, Pa., on March 13, 1848. He attended Pennsylvania (now Gettysburg) College and the University of Michigan,

graduating from the latter institution with the degree of Bachelor of Arts in 1872, and receiving its degree of Master of Arts in 1875. He held an assistantship in astronomy and mathematics in the Central High School from 1873 to 1880, and a professorship from 1880 to 1920, when he became emeritus professor. He was head of the department of mathematics from 1896 to 1920, and became Director of the Philadelphia Observatory in 1897. He served as president of the board of examiners of the International Electrical Exhibition of 1884, and was secretary of the United States Electrical Commission and of the National Conference of Electricians which met at that time. He made noteworthy observations of the transit of Mercury in 1878, and the transit of Venus in 1882, and had been interested more recently in astrophysics, and atomic weights. *The Mirror*, the organ of the School (vol. 67, no. 1, pages 6–9, November, 1932), contains Professor Snyder's picture, a sketch of his life, and tributes to his work by Drs. Elihu Thomson, J. L. Haney, J. T. Rorer, and J. B. Krause, and Professor E. R. Hill.

J. S. H.

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The John Price Wetherill Medal (Silver Medal).—This medal is awarded for discovery or invention in the physical sciences or for new and important combinations of principles or methods already known.

The Edward Longstreth Medal (Silver Medal).—This medal is awarded for inventions of high order and for particularly meritorious improvements and developments in machines and mechanical processes. In the event of an accumulation of the fund for medals beyond the sum of one hundred dollars, it is competent for the Committee on Science and the Arts to offer from such surplus a money premium for some special work on any mechanical or scientific subject that is considered of sufficient importance.

The Louis E. Levy Medal (Gold Medal).—This medal is awarded to the author of a paper of especial merit, published in the JOURNAL OF THE FRANKLIN INSTITUTE, preference being given to one describing the author's experimental and theoretical researches in a subject of fundamental importance.

The Walton Clark Medal (Gold Medal).—This medal is awarded to the "author of the most notable advance in knowledge or improvement in apparatus, or in method concerning the science or the art of gas manufacture or distribution or utilization in the production of illumination, or of heat, or of power."

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The Boyden Premium.—Uriah A. Boyden, Esq., of Boston, Mass., has deposited with The Franklin Institute the sum of one thousand dollars, to be awarded as premium to "any resident of North America who shall determine by experiment whether all rays of light and other physical rays are or are not transmitted with the same velocity."

For further information relating to these awards apply to the Secretary of the Institute